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CROP COMPOSITION AND YIELD AS AFFECTED BY FERTILIZERS ON BRETON GRAY-WOODED SOIL.

J. W. Kenwood,
University of Alberta.

April 1947.

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This is to certify that the undersigned have read and recommend to the Committee on Graduate Studies for acceptance, a thesis submitted by John Wooster Kenwood, B.Sc., entitled, "Crop Composition and Yield as Affected by Fertilizers on Breton Gray-Wooded Soil".

CROP COMPOSITION AND YIELD AS AFFECTED BY FERTILIZERS ON BRETON GRAY-WOODED SOIL.

John Wooster Kenwood
Department of Soils.

A THESIS

submitted to the University of Alberta in partial
fulfilment of the requirements for the
degree of

MASTER OF SCIENCE.

Edmonton, Alberta. April, 1947.

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CROP COMPOSITION AND YIELD AS AFFECTED BY FERTILIZERS ON BRETON GRAY-WOODED SOIL.

J. W. KENWOOD.

* * * * * * *

INTRODUCTION.

Within recent years Alberta farmers have become increasingly aware of the importance of commercial fertilizers in their farming practices. Crops grown on the gray-wooded soils, which occupy a large portion of the land area of northern and west-central Alberta, seem especially responsive to the use of such fertilizers.

The effects of fertilizers on crop yields can often be quite easily seen in the field; their effects on crop composition, however, are not so easily seen. Examples of serious problems in feeding and breeding of livestock, due to mineral deficiencies in their rations, may be found in practically every country of the world.

In Alberta diseases due to deficiencies of calcium, phosphorus, cobalt and iodine have already been reported from numerous small areas. "Bone chewing", for example, which is caused by the lack of sufficient calcium or phosphorus in the feed, has been a problem of southern Alberta ranchers for many years.

Beeson (6), in an attempt to map the areas in which nutritional diseases of plants and animals have occurred in the United States, reports that the most widespread deficiencies in animals are phosphorus and iodine. Calcium, copper, and iron are also found deficient in many instances. An increase in the number of reports of cobalt deficiencies has occurred in recent years. Deficiencies of magnesium in isolated areas of Ohio have been reported by Kuck (34). Cows suffering from mastitis have been quickly cured by feeding them hay grown on land fertilized with dolomite or by supplementing their feeds with the latter.

Cobalt deficiency diseases are very widespread in New Zealand. Askew and Dixon (3), working with the sheep diseases known as bush-sickness and Morton Mains disease, find them very easily cured by allowing the animals access to pasture treated with cobalt salts. Successful results are also obtained by supplementing feeds with these salts.

Many cases of mineral deficiencies in plant nutrition have been reported in Canada. Deficiencies of one or more of the major elements have occurred in every province. Nitrogen and sulphur are often limiting factors in the production of crops on the gray soils of Alberta, and many of our black soils are deficient in available phosphorus. "Corky core" of apples, caused by a lack of sufficient boron, is a serious problem of Canadian fruit growers. Spraying the leaves with aqueous borax is very effective in controlling this disease, conclude Young and Bailey (57), whereas applications of borax to the soil are of little or no value. McLarty and others (40) report that a distinctive yellowing and stunting of alfalfa, due to a deficiency of boron, has been found to occur commonly wherever this crop is grown in

the Okanagan and Kootenay valleys of British Columbia. This condition is readily remedied by the application of either boric acid or borax to the soil. Boron deficiencies in apricots, causing branches to die and in some cases the death of the entire tree, are reported by Fitzpatrick and Woodbridge (18).

MacLachlan (39) states that manganese is deficient in some of the muck soils of Ontario. Very heavy applications of manganese sulphate to the soil are required to prevent signs of the deficiency from occurring in oats, but spraying the foliage with a dilute manganese sulphate solution is quite effective in this respect.

Hagborg (25) recently reports a disease of oats known as "grey speck" occurring in several areas of Manitoba. Field experiments have shown significant yield increases through the use of manganese sulphate in the affected localities. Soil applications have produced the best results, while its use as a seed steep or application in dust or spray form have also resulted in large increases.

Severe cases of magnesium deficiencies in apple trees in many Canadian orchards have been observed. Hill and Johnston (29) state that the general symptoms are chlorosis, premature fall of older leaves, necrotic leaf browning and death of intervenal tissues. Soil applications of magnesium sulphate, potassium sulphate or magnesian and dolomitic limestones do not prevent the occurrence of this disorder. Numerous farmers in the Saint John River Valley area of New Brunswick have suffered considerable reductions in their potato and grain crop yields because of a lack of sufficient magnesium. Taylor and Howatt (50) report that

the leaves become chlorotic, turn yellow and finally drop off. Increased yields and prevention of this disturbance are obtained by applications of magnesium sulphate or magnesium carbonate to the soil.

Plant nutritional deficiencies of the major elements have occurred very frequently in the United States. Of the so-called "minor" elements, deficiencies of boron, manganese, zinc, copper and iron are reported by Beeson (6) as being most outstanding.

The purpose of this investigation has been to determine the effects of character of soil and applications of fertilizers and amendments on the composition, yield and nutritional value of crops grown in the Breton area.

REVIEW OF LITERATURE.

Much work has been done pertaining to the effect of fertilizers and soil amendments upon the composition of crops. A review of the literature, dealing mainly with forage crops, indicates that the results of various investigators are not in total agreement. Such discrepancies are to be expected because of the great variations in soil, climate and vegetation occurring throughout the country.

Increases in the calcium, nitrogen and phosphorus contents of pasture grasses were found to occur with the application of complete fertilizer in investigations by Brown (11) and Archibald (2). Bender (7) found that the principal effect of such a fertilizer was to increase the nitrogen content of the grass. Similar experiments on alfalfa by Vandecaveye and Bond (52) failed to show any appreciable effect upon the composition of the crop. Bayfield (5) reported that although, in certain cases, these fertilizers produced higher protein percentages in cereal grains, they often caused a depression of this constituent.

Edwards and Goff (16) in Hawaii, studied the effects of the three factors, location, species and season upon the chemical composition of grasses. Location had a strong influence on the absorption of phosphorus and calcium, the phosphorus content in the best section being three times that in the poorest. The variation in the composition of different species was most marked in the case of proteins. An inverse relationship between the percentages of calcium and protein also existed and the highest values for all constituents were reached during the cool winter months. In contrast, Parker and Truog (47) in Wisconsin found a

direct correlation between the calcium and nitrogen content of plants.

Vandecaveye and Dunn (53) working in Washington, found that in the majority of cases the addition of fertilizers to the soil modified the composition of the crop irrespective of the soil type, but that different crops were not affected similarly. The protein content of grass hays was increased by the application of nitrogen alone, in combination with phosphorus, or with phosphorus and potassium. Such results were not obtained for grasses cut as pasture or for alfalfa. Significant increases in percentage of phosphorus in pasture grasses occurred as a result of application of phosphates along with nitrogen or potassium, but in many cases alfalfa and grass hays treated similarly showed no such change in their constituents. Potassium, applied in combination with phosphorus, or nitrogen and phosphorus, produced crops containing increased amounts of this element.

Results of experiments carried out by Hockensmith and others (31), Metzger (43) and Midgley (44), showed that the downward movement of most phosphate fertilizers through soil was exceedingly slow. The depth of application proved of great importance in affecting the crop response to the fertilizer. Metzger (43) and Comber (14) found a close direct relationship existing in acid soils between the total iron and aluminum oxides present and the phosphorus fixing capacity of the soil. Heck (27) included biological agencies and presence of soluble calcium as important factors in the fixation of this element.

Investigations of Fudge (21) indicated that physiologically basic nitrogen fertilizers, such as sodium nitrate, increased phosphate availability, whereas acid-forming fertilizers,

for example ammonium sulphate, decreased the availability. Liming corrected the detrimental effect of the acid-forming fertilizers and greatly increased the amount of available phosphorus.

The work of Brown (11) and Mather (42) on grasses, and that of Blair and Prince (10) on legumes showed that the application of medium to large amounts of phosphatic fertilizers resulted in an increased percentage of phosphorus in the crop obtained. Geddes and others (22) and Bayfield (5) found that such a treatment reduced the protein content and had very little effect upon the phosphorus content of cereals. Vandecaveye and Bond (52) working with alfalfa, came to the conclusion that the nature of the soil greatly affected the results of phosphate fertilization.

H. D. Chapman (13), experimenting with pot cultures, discovered that without exception, plants grown in soils very deficient in phosphates were low in inorganic phosphorus. In contrast, those grown in soils showing no phosphorus deficiency contained considerably more of this element. It was further shown that plants already high in inorganic phosphorus gave no yield increase with the addition of a phosphate fertilizer. His results, and also those of McCool and Weldon (38), indicated that if one element was a decidedly limiting factor, the plant would accumulate high concentrations of other elements.

Ellis and Caldwell (17), working with peat and mineral soils of Manitoba, found that phosphatic fertilizers increased the phosphorus content of hays only when such treatment produced increased crop yields.

Albrecht and Smith (1) reported that a larger share of applied phosphorus was recovered in the crops of both legumes and

non-legumes when used in conjunction with lime than when used alone. The same investigators suggested a complementary effect existing between the percentage of calcium and phosphorus in the plant.

The liming of acid soils in many instances, but not all, increased the percentage of phosphorus in the plants, concluded Brown and Hollowell (12). Weeks and others (54) found that the phosphorus content of the crop varied directly with the amount supplied to the soil. They also found that where limestone was used with the phosphate, the percentage of phosphorus in the crop decreased, and the calcium increased over those plots where phosphorus was applied alone. On the other hand, Albrecht and Smith (1) found that liming did not significantly affect the percentage of phosphorus in either legumes or non-legumes.

Liming had little effect upon the total yield of non-leguminous crops when grown on a New Jersey acid loam soil, reported Lipman and others (37). It was further found that the nitrogen content of the crop was increased significantly only when very large amounts of nitrogenous fertilizers were applied. Otherwise the difference in percent nitrogen between the limed and unlimed plots was not great.

When legumes were included in a rotation, fertilized with calcium or magnesium limestone, significant yield increases were obtained by Lipman and Blair (36) on soils originally acid in reaction. Over the ten year period recorded the limed plots, with very few exceptions, yielded distinctly larger crops, with higher percentages of nitrogen than did the unlimed plots. The value of the lime was attributed to its stimulation of soil microorganisms. Lipman and Blair (36) and Cook (15) found that

small applications of lime proved practically as efficient as larger quantities.

Upon comparing the mineral content of thirty-four different plant species, Parker and Truog (47) found a direct relationship existing between their calcium and nitrogen levels. The contents of potassium, phosphorus and magnesium showed no similar correlation. It was theorized that the amino acids produced as by-products of protein metabolism were neutralized through the uptake of larger amounts of calcium by the plants. Newton (45) grew barley and peas in nutrient solutions and found it possible to decrease the amount of calcium absorbed to quite a low level without materially affecting the absorption of nitrogen. He obtained evidence, furthermore, that the pH of the sap was not appreciably decreased by limiting the plants' supply of calcium.

Weeks and others (54) after analyzing three corn crops, each consisting of two different varieties, from two Kentucky soil experimental farms, came to the conclusion that on an average the nitrogen content of grain was somewhat increased by the application of limestone and phosphates. The magnesium content was generally higher from limed soils though the results were not consistent.

MacTaggart (41) grew legumes in very infertile sand cultures and found that any fertilizer, with the possible exception of sulphur, which increased crop yield also increased the nitrogen content. Phosphates were most effective in this respect.

Application of nitrogenous fertilizers appeared to increase the sulphur and carotene content of Connecticut pasture

grasses as reported by Brown (11). When such fertilizers were supplemented with phosphates, increased percentages of phosphorus, calcium and nitrogen in the herbage generally resulted.

Soybeans, growing in solutions each lacking in one essential element, always absorbed higher percentages of calcium and lower percentages of both nitrogen and magnesium than did those plants growing in complete nutrient solutions, except in solutions lacking sulphur, concluded Ginsburg (23). An inverse correlation between the content of calcium and that of magnesium and nitrogen in the plant also occurred. On the other hand, as stated previously, Parker and Truog (47) found a direct correlation existing between the calcium and nitrogen levels in plants. Ginsburg and Shive (24) reported a direct correlation between the amount of calcium in the nutrient solution and the calcium content of the plant. No such relationship was observed in the case of nitrogen. Plants showed higher rates of nitrogen absorption in the presence of calcium carbonate than in the presence of other calcium compounds, but the protein nitrogen did not increase.

Cook (15), Pendleton (48) and Blair (9) found that the protein content of barley, oats and wheat could be increased by application of nitrogenous fertilizers. In contrast, results of experiments by Baker and Vandecaveye (4) with oats grown on various soil types showed that such applications had no effect upon their protein contents at the hay stage of maturity. The phosphorus and calcium contents of the crop were depressed by the use of nitrogenous fertilizers.

Hoagland (30) stated that a definite interrelationship existed between the absorption of potassium, calcium and magnesium in plants. An increase in the absorption of potassium was found

to decrease that of calcium and magnesium, but the reverse was often much less marked. Ammonium ions retarded potassium absorption whereas nitrate ions accelerated the absorption of the latter.

Fonder (20) found that the amount of calcium present in pea plants varied directly with the calcium content of the soil, but that the magnesium content suggested correlation only with soil texture. In another paper (19) the same author reported no correlation between the soil texture and the magnesium content of alfalfa.

The lodging of cereals was at one time attributed to the lack of silicic acid in the cell walls of the plant, which caused a weakening of the supporting power of the culms. More recently it was shown that the difference between the silicic acid content of normal stiff straw and lodged straw was very slight and that a small amount of silicic acid was sufficient for the production of normal crops.

Jennings (33) and Lipman (35) obtained definite yield increases by the addition of colloidal silicon dioxide to nutrient solutions. The entire absence of silicon, however, did not show any harmful effects, other than yield decreases, upon the plants.

Toth (51) reported that the absorption of increased amounts of phosphorus was generally associated with higher absorption of silica. This investigator, furthermore, found that a definite increase in the yields of barley and sudan grass was produced where calcium or magnesium silicates were applied. Very marked increases in silica absorption occurred when rape, barley, and sudan grass were grown on silicated soils, but only slight changes in the amounts of their other constituents were obtained.

Schollenberger (49) found that applications of air-dry hydrated silica, dialyzed silica, blast furnace slag, calcium silicate and sodium silicate were all successful in increasing the percentage of silica in crops. Soybeans, oats and buckwheat were grown separately in Wooster (Ohio) silt loam and were treated with lime, phosphates and the aforementioned silicates. The majority of the pots to which additions of silica compounds and calcium carbonate, but no phosphates, were made showed increased yields and phosphorus content of the crop as compared to the pots receiving only calcium carbonate. The soybeans were higher in phosphorus in those pots where silicates were used in place of lime.

MATERIALS.

The crop samples analyzed were grown on the gray-wooded soil of the Breton district in conjunction with the fertilizer plot experimental work of the University Department of Soils.

The soils of Alberta are divided into five major zones - the brown, the dark brown, the shallow black, the black and the gray-wooded. A transitional area of black-gray and gray-black soils occurs between the black and wooded soil zones.

The brown soils, occupying approximately twelve million acres, are found in the south eastern part of the province. Moisture is the principal limiting factor for crop production. Frequent drought, high evaporation and hot dry winds are characteristic of the area. The A horizon of the normal profile is about five inches deep and brown in colour. The B horizon is also usually brown and the lime layer (BCa) is found at an average depth of fifteen inches below the surface. The brown soils are relatively low in nitrogen and often respond to phosphorus fertilizers under irrigation.

Immediately to the north and west of the brown zone, and varying in width from twenty-five to sixty miles, lies the dark brown zone. It occupies about eight million acres. In the normal profile the surface (A) horizon averages seven inches in depth and is dark brown in colour. The B horizon is brownish and the lime layer is found at a depth of twenty to twenty-four inches. Although moisture is the main limiting factor in crop production, droughts occur less frequently than in the brown zone.

Occupying approximately seven million acres between the dark brown zone and the black zone is found an area of shallow black soil. The upper three to six inches of the A horizon is black in colour; the remaining four to seven inches is dark brown. The B horizon is usually brown to dark brown and the lime layer (BCa) is found at depths varying from about twenty-four to thirty inches below the surface. Droughts occur only occasionally in this area. The soil is relatively fertile, being fairly well supplied with nitrogen and organic matter.

About seven million acres of land, constituting the black soil zone, lie to the north and west of the aforementioned zones. Hot dry winds are infrequent, and droughts are rare in this area. The normal profile has a very dark brown surface (A) horizon. The more compact B horizon is brown to dark brown and is underlain by a lime layer (BCa) about thirty to forty inches from the surface. Soils in this zone are the most fertile in the province. The crops grown here often respond well to phosphatic fertilizers.

A transitional area of black-gray and gray-black soils lies between the black and the gray-wooded zones. The colour of the profile is quite variable, ranging from nearly black to gray. The A horizon averages ten to twelve inches deep. The surface horizon consists of a thin layer of semi-decomposed forest litter (A_0) often absent in burned over areas. The A_1 horizon is black, dark brown or gray black, and the A_2, commonly somewhat leached of organic matter, is considerably grayer than the A_1. The B horizon is usually dark brown in colour and the lime layer (BCa) occurs at a depth of about thirty to forty inches. These soils are not usually as fertile as those of the black zone since leaching of the surface horizons has removed more of the plant foods.

Evaporation is low in this area and the annual precipitation varies from twelve inches in the northern section to twenty inches in the southern.

The gray-wooded soils, situated to the north and west of the other zones, occupy a large portion of the land area of Alberta. About thirty-two million acres are now recognized as being gray-wooded. The remainder of the province, not yet surveyed*, and still quite inaccessible, is also believed to consist mainly of wooded soil.

These soils have developed under humid soil moisture conditions, cool temperatures and low evaporation. The surface horizon consists of a semi-decomposed leaf mould layer (A_0), often absent if the area has been burned over; a thin (sometimes absent) gray black, brown or gray brown A_1 horizon and a platy, severely leached grayish A_2 horizon present to a depth of about six to eight inches below the surface. The B horizons are heavier textured and often darker in colour than the A. The depth to the lime layer varies from thirty to fifty inches.

A mixed deciduous and evergreen vegetation occurs throughout the zone. Peats and muskegs are frequently found. The annual precipitation varies from about twelve inches in the northern section to about twenty inches in the southern.

The gray-wooded zone is a mixed farming zone. Rotations consisting of coarse grains, grass hays and legumes and supplemented with fertilizers where required have given the most satisfactory results.

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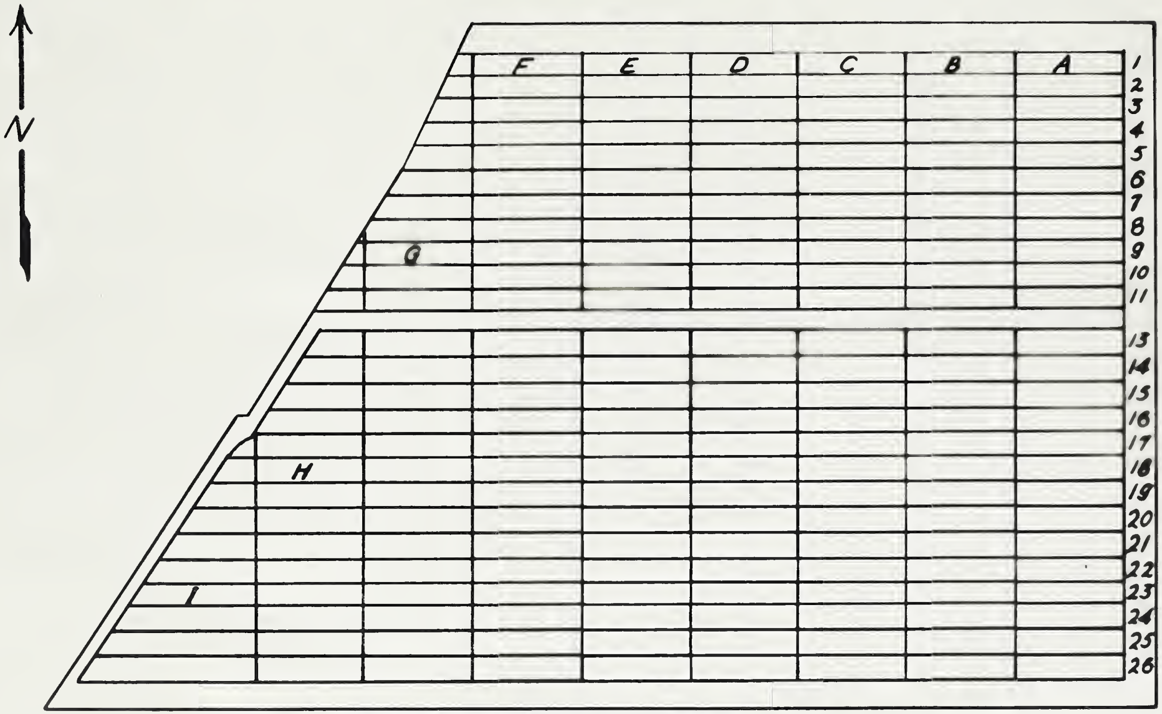
*As established by Alberta Soil Surveys: Department of Soils, University of Alberta; Experimental Farms Service; Alberta Research Council, and Department of Agriculture.

Any great further expansion of farming in Alberta must be made into the wooded soil area because here is found the largest amount of arable land still not under cultivation. Farming is somewhat more difficult in this zone as the soils are for the most part less fertile than in the other zones. They do, however, compare favorably with the average cultivated soils of the world. The soil on the Breton fertilizer experimental field is considered fairly typical of the gray-wooded type, although more degraded than some found in Alberta.



Size of a full plot, e.g. Series A, Plot 2, is 1/11 acre.

— BRETON FIELD PLOTS. —

Fig. 1.

Plan of the Breton Experimental Field.

The Breton experimental field (Figure 1, page 17) is located about two miles south and east of the town of Breton.

The original plan as commenced in 1929 consisted of plots one to eleven, and extended over series A to G inclusive. Series A, B, C and D were cropped on a four year rotation system consisting of one year each of wheat, oats, barley nursing clover and clover. After two complete four year courses were passed through, Series F was included, thus making a five year rotation. This made it possible to have clovers occupying the land for two years out of every five. Series E has been farmed on a wheat-fallow system continuously, with the exception of 1945, when barley was grown in the place of wheat. Series G has at different times grown barley, clovers and flax.

In 1939 plots thirteen to twenty-six were added to all series, making it possible to experiment with other fertilizers and combinations of fertilizers. These plots had previously grown clovers and occasionally grain crops.

The total amounts of fertilizers applied to all plots are listed in Table I, page 19. During the early years of the experiment some of the fertilizers were not always available. In these cases substitutions of similar products were made.

The crop history of the field from 1941 to 1946 inclusive is shown in Table II, page 20.

Table I. Fertilizers Applied to Breton Plots 1930 to 1946 (17 Years)*.

Plot	Standard Fertilizer Treatment	Manure tons	16-20-0 lbs.	11-48-0 lbs.	21-0-0 Amm. sulphate lbs.	0-43-0 Triple super lbs.	Lime lbs.	2-20-0 Super-phos. lbs.	0-20-0 Super-phos. lbs.	Bone lbs.	33-0-0 Amm. nitrate lbs.	Gyp-sum lbs.	Sod. sul-phate lbs.	Pot. sul-phate lbs.	Total applied in 17 yrs.
2	Manure	110													110 tons
3	Complete 16-20-0 + K_2SO_4		844	300		45								589(1)	1778
4	Amm. sulphate				1173(2)										1173
6	Lime						4850								4850
7	Lime + Triple super.					1115	4850								5965
8	Triple super.					1115									1115
9	Manure + 16-20-0	110	405			667									1072 + M. 110 tons
10	16-20-0		805	300		50									1155
	New Plots Added 1939.														
14	11-48-0			914		100									1014
15	Super. 2-20-0		276	190		100		650							1216
16	Super. 0-20-0				150(4)				651						801
17	Bone				150(4)					2210					2360
19	Amm. nitrate				150(4)						435(3)				585
20	Amm. nitrate + Gypsum				150(4)						435(3)	976			1561
21	Gypsum				150(4)							976			1126
23	Sod. sulphate				150(4)								748		898
24	Pot. sulphate				150(4)									552	702
25	Pot. sulphate + amm. sulphate				609(4)									571	1180

* In some instances the desired fertilizers were not available and it was then necessary to substitute a similar product. Such fertilizers as manure, lime, bone and gypsum were applied at intervals and not annually. In 1945 no fertilizers were applied. (1) 154 lbs. were potassium chloride, (2) 220 lbs. were calcium nitrate, (3) 96 lbs. were sodium nitrate, (4) 150 lbs. applied previous to 1939.

Table II. Crop History of the Breton Field from 1941-46.

Series	Plots	1941	1942	1943	1944	1945	1946
A	1-26	Oats	Barley with clovers	Clovers	Clovers	E2/3 Barley W1/3 Wheat	Barley
B	1-26	Wheat	Oats	Barley with Clovers	Clovers	Clovers	E1/2 Wheat W1/2 Barley
C	1-26	Clovers	Wheat	Oats	Barley with Clovers	Clovers	Clovers
D	1-26	Clovers	Clovers	Wheat	Oats	Barley with Clovers	Clovers
E	1-26	Wheat after Fallow	Wheat after Fallow	Wheat after Fallow	Wheat after Fallow	Barley after Fallow	Wheat after Fallow
F	1-26	Barley with Clovers	Clovers	Clovers	Wheat	Barley	Barley with Clovers
G	1-26	Clovers	Flax (1-11) Alfalfa (13-26)	Clovers (1-11) Alfalfa (13-26)	Fallow	Wheat with Alfalfa	Alfalfa
H	13-26	Alfalfa	Alfalfa	Alfalfa	Alfalfa	Alfalfa	Alfalfa

METHODS.

Sampling.

A minimum of four crop samples, each one square yard in area, was cut at random from every plot. The individual samples were combined and weighed to give yield data and then thoroughly mixed together in an effort to form a representative sample. A portion was then removed, coarsely ground in a Wiley Mill and analyzed.

Analysis.

Nitrogen was determined by the Kjeldahl-Gunning method (46), modified by the addition of selenium as a catalyst. Protein on all samples was recorded as 6.25 x the nitrogen content.

Phosphorus was precipitated as the yellow ammonium phosphomolybdate, filtered, dissolved in standard base and determined volumetrically as recommended by official methods (46).

Ash, silica, calcium and magnesium were determined on the same sample. That portion remaining after igniting at 550°C for twelve hours was recorded as ash. The insoluble residue left after treating the ash with hydrochloric acid, evaporating to dryness and taking up with hydrochloric acid was considered as silica. Calcium was determined volumetrically by official methods (46). The "alkalimetric titration method" developed by Handy (26) and recommended by Wright (56) was followed for determining magnesium.

RESULTS.

Composition and Yield of Second Year Clovers, Series A, 1944.

The crop grown on Series A, in 1944, consisted of a mixture of red (Altaswede) clover and alfalfa.

The yield (Table IV) varies greatly with the different fertilizer treatments. The lowest yield is less than 1/4 ton per acre and the highest is over 3 tons per acre.

The yield of the check plots varies considerably, indicating some variation in the initial fertility of the soil.

Most types of fertilizers have resulted in increased yields of these clovers as compared to the check plots.

No yield increase has resulted through the application of lime to this soil. Triple super phosphate applied along with lime has produced a slight increase in yield, but not sufficient to warrant its use.

Manure, as applied to plot 2, has produced a crop of over 2 tons per acre and when used in conjunction with ammonium phosphate (16-20-0) has produced a yield of over 3 tons per acre. The beneficial effect of the ammonium phosphate may lie in the fact that it contains approximately 14 percent sulphur.

Without exception, those fertilizers containing sulphur have produced significant yield increases and satisfactory yields. Single superphosphate, which contains 2 percent nitrogen, 19 percent P_2O_5, and 9 percent sulphur, has produced the highest yield - over 3 1/4 tons of clover to the acre. Sulphur is apparently a limiting element in the production of clovers on Series A.

Table III. Yield and Percent Composition of Second Year Clovers Grown on Gray Wooded Soil (Oven-dry basis).

Breton Series A, 1944, First Cutting.

Plot No.	Treatment	Yield lbs. per acre	% Nitrogen	% Protein	% Phosphorus	% Calcium	% Magnesium	% Silica	% Ash
2	Manure	4314	2.18	13.63	.33	1.33	.31	.38	9.17
3	N+P+K+S(A.P.+P.S.,16-20-48)	5348	2.65	16.56	.30	1.34	.36	.66	7.84
4	N+ S(A.S.21-0-0)	5244	2.39	14.94	.25	1.23	.40	.72	7.19
5	Check	345	2.20	13.75	-	1.68	.36	2.09	8.75
6	Lime	379	2.26	14.13	.41	1.69	.34	2.17	9.26
7	Lime + P(T.Sp.0-43-0)	1164	2.01	12.56	.32	1.57	.27	1.26	7.80
8	P (T.Sp.0-43-0)	1250	1.81	11.31	.30	1.50	.27	1.75	8.25
9	Manure +N+P+S(A.P.16-20-0)	6572	2.40	15.00	-	1.17	.27	.62	9.24
10	N+P+S(A.P.16-20-0)	5854	2.40	15.00	.26	1.23	.35	.29	7.48
11	Check	597	2.43	15.19	.33	1.55	.35	1.54	8.84
14	N+P(A.P.11-48-0)	2068	1.93	12.06	.26	1.53	.32	.34	7.57
15	N+P+S(S.Sp.2-19-0)	6728	2.41	15.06	.25	1.50	.35	.29	7.82
16	P+S(S.Sp.0-20-0)	6065	2.36	14.75	.26	1.24	.29	.49	7.78
17	P(B.M.4-20-0)	1379	2.24	14.00	.33	1.53	.36	.96	8.12
18	Check	804	2.13	13.31	.31	1.54	.35	1.17	8.24
19	N(A.N.34-0-0)	1133	2.53	15.81	.32	1.58	.36	.69	8.56
20	Gyp.+N+S(A.N.34-0-0)	5465	2.28	14.25	.29	1.34	.33	.66	8.11
21	S(Gyp.)	5499	2.24	14.00	.28	1.31	.28	.34	8.13
22	Check	2493	2.21	13.81	.28	1.39	.30	.30	7.86
23	S(Sod.S.)	5330	2.39	14.94	.24	1.27	.27	.49	8.95
24	K+S(P.S.0-0-48)	5018	2.51	15.69	.25	1.24	.26	.31	8.97
25	N+K+S(P.S.+A.S.,21-0-48)	6065	2.28	14.25	.19	1.31	.27	.32	8.45

A.P. - Ammonium phosphate; P.S. - Potassium sulfate; A.S. - Ammonium sulfate; T.Sp. - Triple superphosphate; S.Sp. - Single superphosphate; B.M. - Bone meal; A.N. - Ammonium nitrate; Gyp. - Gypsum; Sod.S. - Sodium sulfate.

Table IV. Yield and Composition in Pounds per Acre of Second Year Clovers Grown on Gray Wooded Soil.

Breton Series A, 1944, First Cutting.

Plot No.	Treatment	Yield per ac. (air-dry basis)	Lbs. per acre						
			Nitrogen	Protein	Phosphorus	Calcium	Magnesium	Silica	Ash
2	Manure	4643	94	588	14	57	13	16	396
3	N+P+K+S(A.P.+P.S.,16-20-48)	5756	142	886	16	72	19	35	419
4	N+S(A.S.21-0-0)	5644	125	783	13	65	21	38	377
5	Check	371	8	47	-	6	1	7	30
6	Lime	408	9	54	2	6	1	8	35
7	Lime + P(T.Sp. 0-43-0)	1253	23	146	4	18	3	15	91
8	P(T.Sp. 0-43-0)	1345	23	141	4	19	3	22	103
9	Manure +N+P+S(A.P.16-20-0)	7074	158	986	-	77	18	41	607
10	N+P+S(A.P.16-20-0)	6301	140	878	15	72	20	17	438
11	Check	643	15	91	2	9	2	9	53
14	N+P(A.P.11-48-0)	2226	40	249	5	32	7	7	157
15	N+P+S(S.Sp.2-19-0)	7241	162	1013	17	101	24	20	526
16	P+S(S.Sp.0-20-0)	6528	143	895	16	75	18	30	472
17	P(B.M.4-20-0)	1484	31	193	5	21	5	13	112
18	Check	865	17	107	2	12	3	9	66
19	N(A.N.34-0-0)	1219	29	179	4	19	4	8	97
20	Gyp.+N+S(A.N.34-0-0)	5882	125	779	15	73	18	36	443
21	S(Gyp.)	5919	123	770	15	72	15	19	447
22	Check	2683	55	344	7	35	7	7	196
23	S(Sod.S.)	5737	127	796	13	68	14	26	477
24	K+S(P.S.0-0-48)	5401	126	787	13	62	13	16	450
25	N+K+S(P.S.+A.S.,21-0-48)	6528	138	864	12	79	16	19	512

Table V. Percent Composition of Second Year Clovers Grown on Gray Wooded Soil (Oven-dry basis).
Data Grouped According to Yield or Treatment.

Breton, Series A, 1944.

Plot Description	Plots Included	%N2		% Prot.		% P		% Ca		%Mg		%SiO2		% Ash	
		Rge.	Av.	Rge.	Av.	Rge.	Av.	Rge.	Av.	Rge.	Av.	Rge.	Ave.	Rge.	Av.
Checks	5,11,18,22	2.13 2.43	2.24	13.75 15.19	14.02	.28 .33	.31	1.39 1.68	1.54	.30 .36	.34	.30 2.09	1.28	7.86 8.84	8.42
Low Yielders Rec. phos.	7,8,14,17	1.81 2.24	2.00	11.31 14.00	12.48	.26 .33	.30	1.50 1.57	1.53	.27 .36	.31	.34 1.75	1.08	7.57 8.25	7.94
High Yielders Rec. phos.	3,9,10,15,16	2.36 2.65	2.44	14.75 16.56	15.27	.25 .30	.27	1.17 1.50	1.30	.27 .36	.34	.29 .66	.47	7.48 9.24	8.03
All Plots Rec. phos.		1.81 2.65	2.25	11.31 16.56	14.03	.25 .33	.29	1.17 1.57	1.40	.27 .36	.32	.29 1.75	.74	7.48 9.24	7.99
Plots Rec. Manure	2,9	2.18 2.40	2.29	13.63 15.00	14.32	.33 -	.33	1.17 1.33	1.25	.27 .31	.29	.38 .62	.50	9.17 9.24	9.21
Sulphur with Phos.	3,9,10,15,16	2.36 2.65	2.44	14.75 16.56	15.27	.25 .30	.27	1.17 1.50	1.30	.27 .36	.32	.29 .66	.47	7.48 9.24	8.03
Sulphur without phos.	4,20,21,23, 24,25	2.24 2.51	2.35	14.00 15.69	14.68	.19 .29	.25	1.23 1.34	1.28	.26 .40	.30	.31 .72	.48	7.19 8.97	8.30
All Rec. sulphur		2.24 2.65	2.39	14.00 16.56	14.95	.19 .30	.26	1.17 1.50	1.29	.26 .40	.31	.29 .72	.47	7.19 9.24	8.18

.....continued next page

Table V. cont'd.

Plot Description	Plots Included	%N_2		% Prot.		% P		% Ca		%Mg		%SiO_2		% Ash	
		Rge.	Av.	Rge.	Av.	Rge.	Av.	Rge.	Av.	Rge.	Av.	Rge.	Av.	Rge.	Av.
Nitrogen with phos.	3,9,10,14	1.93 2.65	2.35	12.06 16.56	14.66	.26 .30	.27	1.17 1.53	1.32	.27 .36	.33	.29 .66	.48	7.48 9.24	8.03
Nitrogen without phos.	4,19,20,25	2.28 2.53	2.37	14.25 15.81	14.81	.19 .32	.26	1.23 1.68	1.39	.27 .40	.34	.32 .72	.60	7.19 8.56	8.08
All Rec. nitrogen		1.93 2.65	2.36	12.06 16.56	14.73	.19 .32	.27	1.17 1.68	1.35	.27 .40	.33	.29 .72	.54	7.19 9.24	8.06
High Yielders	2,3,4,9,10, 15,16,20,21, 23,24,25	2.18 2.65	2.37	13.63 16.56	14.84	.19 .33	.26	1.17 1.50	1.29	.26 .40	.31	.29 .72	.46	7.19 9.24	8.26
Low Yielders	5,6,7,8,11, 14,17,18,19, 22	1.81 2.53	2.18	11.31 15.81	13.59	.26 .41	.32	1.39 1.69	1.57	.27 .36	.33	.30 2.17	1.23	7.57 9.26	8.33
All Fertilized Plots		1.81 2.65	2.29	11.31 16.56	14.33	.19 .41	.29	1.17 1.69	1.39	.26 .40	.31	.29 2.17	.71	7.19 9.26	8.26
All Plots		1.81 2.65	2.28	11.31 16.56	14.27	.19 .41	.29	1.17 1.69	1.42	.26 .40	.32	.29 2.17	.81	7.19 9.26	8.29

The Nitrogen and Protein Content.*

Considerable variation in the nitrogen and protein content of these clovers is evident (Table III), the contents varying from 1.81 percent nitrogen as the lowest and 2.65 percent as the highest. The protein, obtained by multiplying the nitrogen content by 6.25, varies from 11.31 to 16.56 percent. The average percentage of nitrogen over all the plots is 2.28 percent and protein is 14.27 percent. Henry and Morrison (28) give 2.1 percent nitrogen and 13.1 percent protein, and Hopkins (32) gives 2.0 percent nitrogen and 12.5 percent protein as average contents for red clovers. These figures indicate that the majority of clovers on Series A are well supplied with nitrogen and contain on an average slightly above normal amounts of protein.

The amount of nitrogen removed by the crop varies greatly according to the fertilizer treatment and subsequent crop yield. The lowest yielding plot has removed only 8 pounds of nitrogen per acre whereas the highest yielding plot has removed 162 pounds per acre.

The average nitrogen content of all the fertilized crops, is 2.29 percent (Table V), as compared to 2.24 percent for the checks. The effect of the fertilizers in general has been at least to maintain the nitrogen level and in many cases slightly increase it.

The average nitrogen content of the low yielding plots is 2.18 percent, whereas that of the high yielding plots is 2.37

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*Nitrogen data for years 1944 and 1945 obtained from University of Alberta Department of Soils.

percent. Those treatments which have encouraged increased yields have apparently led to increased nitrogen content of the crop.

Those plots receiving nitrogen alone, or with phosphorus, show a percentage of nitrogen of 2.36, or .12 percent higher than the nitrogen content of the checks. Plots receiving nitrogen plus phosphorus have the same average nitrogen content as those receiving nitrogen without phosphorus.

The low yielding plots receiving phosphorus have a relatively low nitrogen content as compared to the average whereas those plots receiving phosphorus and producing a high yield have produced hay with high nitrogen content. The average percentage nitrogen of all plots receiving phosphorus is the same as that of the check plots.

The application of manure, alone, has somewhat decreased the nitrogen content of the crop, whereas its application with ammonium phosphate (16-20-0) has increased the nitrogen content.

Crops receiving both sulphur and phosphorus show a percentage of nitrogen considerably higher than those receiving any other treatment. Those grown on plots receiving sulphur without phosphorus also show a high nitrogen content and the average percent nitrogen of all plots receiving sulphur is 2.39 percent, or .15 percent above the average of the check plots.

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The Phosphorus Content.

The phosphorus content of the crop on Series A varies quite widely with the different fertilizer applications. The highest content, .41 percent, is from the limed plot, whereas the lowest content, .19 percent, is in the crop from plot 25, receiving potassium sulphate and ammonium sulphate. The average percentage phosphorus over the entire series is .29 percent. Data from reliable sources ((28) and (32)) place the average phosphorus content of red clover between .17 and .25 percent. From these figures it appears that this crop is well supplied with phosphorus, plot 25 being the only one approaching the lower limit.

The limed plot and several of the check plots have removed as little as 2 pounds of phosphorus per acre. Many of the high yielding plots have removed from 13 to 16 pounds, and the highest yielding plot has removed 17 pounds of phosphorus per acre.

The average phosphorus content of the high yielding plots is .26 percent and of the low yielding plots is .32 percent. This indicates that those treatments tending to increase the yield of clovers cause a slight lowering of their phosphorus content. The higher yielding plots apparently utilize the phosphorus more efficiently than do the plots producing lower yields. The average phosphorus content of all the plots receiving fertilizers is much the same as that of the checks. The fertilizers in general, then, have not affected the phosphorus content of the clover on Series A.

The average percentages of phosphorus of the high and low yielding plots receiving phosphorus are quite similar. The phosphorus content of all plots receiving phosphorus is .29 percent, the same as the average for all plots in the series. Evidently the phosphatic fertilizers have not significantly affected the phosphorus content on Series A.

Plots receiving sulphur and phosphorus have about the same percentage of phosphorus in their crops as those plots receiving sulphur without phosphorus.

The application of phosphorus appears to slightly decrease the contents of calcium, magnesium, silica and ash found in the crop, although the differences are not large. The nitrogen content has not been affected by the phosphatic fertilizers.

The Calcium Content.

The calcium content of the crop grown on Series A varies from 1.17 percent to 1.69 percent. The average content over the whole series is 1.42 percent. Henry and Morrison (28) give the average calcium content found in red clover as 1.14 percent and Wolff (55) gives the average as about 1.70 percent. The clovers appear to contain close to normal amounts of calcium according to these data.

Plots 5 and 6 have removed only 6 pounds of calcium per acre from the soil, whereas some of the higher yielding plots, for example 9, 10, 15 and 25, have removed much larger quantities. The single superphosphate plot (2-19-0) has removed calcium at the rate of 101 pounds per acre, while the plot receiving manure

plus ammonium phosphate (16-20-0) and that receiving potassium sulphate plus ammonium sulphate have removed 77 and 79 pounds of calcium per acre, respectively.

The average calcium content for the high yielding plots is 1.29 percent, or .25 percent below that of the check plots. The average content for the low yielding plots is about the same as that for the checks. An increase in yield of hay on this series appears to be accompanied by a decrease in the calcium content.

The average calcium content for all the fertilized plots is 1.39 percent. Comparing this to an average of 1.54 percent for the checks, it appears that the effect of fertilizer has been to decrease the calcium content and increase the efficiency of utilization of this element.

Any effect of lime on the calcium content of the clover on Series A is quite doubtful. The percentages of calcium on plots 6 and 7, which received lime, are high, but some of the other plots, for example 5, which is a check plot, and 19, receiving ammonium nitrate, are also high. The soil appears to be well supplied with available calcium.

The Magnesium Content.

The magnesium content of the crops grown on the different plots in this series varies from .26 to .40 percent, the greater majority falling within the range of .27 to .36 percent. The plot receiving ammonium sulphate contains the highest amount of this element. The average magnesium content throughout the entire series is .32 percent. Henry and Morrison (28) place the average content of red clover as .27 percent, so apparently the hay grown on Series A is not deficient in this element.

Several of the lower yielding plots have removed as little as 1 pound of magnesium per acre, but the higher yielding plots, for example plot 3, receiving ammonium phosphate (16-20-0) plus potassium sulphate, and plot 10, receiving ammonium phosphate (16-20-0) have removed approximately 20 pounds of magnesium per acre. Plot 15, treated with single super phosphate, has removed 24 pounds of magnesium per acre.

The average percentage of magnesium for the higher yielding plots is .31 percent, and for the lower yielding plots is .33 percent. The checks show an average content of .34 percent and the average of all the fertilized plots is .31 percent. Evidently neither the yield nor the fertilizers in general have had much effect upon the magnesium content of the crop.

Manure application appears to have resulted in a slight lowering of the magnesium content but the other fertilizers applied either alone or in different combinations have produced even less significant trends.

The Silica Content.

A wide variation in the silica content of the clovers has been found to exist. The amounts range from a lower limit of .29 percent to an upper limit of 2.17 percent. Data given by Wolff (55) and Henry and Morrison (28) give the average silica content of red clover as .21 and .17 percent respectively. As was previously stated, the silica reported in this work may include small amounts of other insoluble residues, but nevertheless, these crops appear to be above average in their silica contents.

The average of all the fertilized plots shows the silica content to be .71 percent as compared to 1.28 percent for the check plots. Apparently the effect of the fertilizer has been to decrease the quantity present in the plant.

The high yielding plots have an average silica content of .46 percent whereas the low yielding plots contain on an average 1.23 percent. It is pointed out that samples from the low yielding plots often contain considerable proportions of other plants, such as horse-tail and grasses, which plants are quite high in silica as reported by Bergen. (8).

The Ash Content.

The percentage ash of the clovers grown on Series A lies between the limits of 7.19 and 9.26, with an average amount of 8.29 percent. Henry and Morrison (28) give 7.4 percent as the average ash content of red clovers, while Wolff (55) gives it as 6.9 percent. These crops are relatively high in non-combustible matter, being mostly above the amounts cited by these authorities.

Manure tends to increase the percentage ash in this crop as evidenced by the fact that the manured plots average .79 percent higher in this constituent than do the checks.

The effect of all other fertilizers seems to be to slightly decrease the ash content of the crop.

Composition and Yield of First Year Clovers, Series B, 1944.

Analytical data are given in Tables VI and VII for a few plots of first year red clover and alfalfa grown on Series B and sampled on July 10th and again on September 9th, 1944. Since samples from the same plots were not retained from both cuttings any comparisons made must be general.

The yield from the second cutting is considerably lower than from the first. The manure plus ammonium phosphate (16-20-0) plot, first cutting, has produced over 5,000 pounds of hay per acre, whereas somewhat comparable plots have yielded less than half this amount from their second cutting.

Yields were estimated for some of these plots from data obtained from others appearing similar in the field. The yields and responses of these clovers to the different fertilizers are quite similar to those of the second year clovers on Series A.

The nitrogen content of the crop from the second cutting is appreciably higher than from the first cutting, the average increase in nitrogen being close to one percent. The phosphorus, calcium, magnesium and ash contents are also somewhat higher. The silica content, on the other hand, seems slightly lower for the second cutting than the first.

Table VI. Yield and Percent Composition of First Year Clovers Grown on Gray Wooded Soil (Oven-dry basis).

Breton Series B, 1944, First Cutting.

Plot No.	Treatment	Yield lbs. per acre	% Nitrogen	% Protein	% Phosphorus	% Calcium	% Magnesium	% Silica	% Ash
5	Check	808	1.78	11.13	.28	1.58	.27	1.67	7.84
9	Manure + N+P+S(A.P.16-20-0)	5284	2.07	12.94	.28	1.04	.25	.76	7.65
11	Check	954	1.67	10.44	.29	1.02	.17	1.63	6.55

Breton Series B, 1944, Second Cutting.

Plot No.	Treatment	Yield lbs. per acre	% Nitrogen	% Protein	% Phosphorus	% Calcium	% Magnesium	% Silica	% Ash
3	N+P+K+S(A.P.+P.S.,16-20-48)	2355	3.42	21.38	.31	1.67	.32	.40	8.28
10	N+P+S(A.P.16-20-0)	2355	3.40	21.25	.34	1.71	.24	.46	8.85
14	N+P(A.P.11-48-0)	252	2.55	15.94	.33	2.26	.27	.62	8.71
15	N+P+S(S.Sp.2-19-0)	2355	3.23	20.19	.27	1.59	.27	.35	7.93
21	S(Gyp.)	2355	3.49	21.81	.28	1.70	.22	.10	7.66

Table VII. Yield and Composition in Pounds per Acre of First Year Clovers Grown on Gray Wooded Soil.

Breton Series B, 1944, First Cutting.

Plot No.	Treatment	Yield per.ac. (air-dry basis)	Lbs. per acre						
			Nitrogen	Protein	Phosphorus	Calcium	Magnesium	Silica	Ash
5	Check	865	14	90	2	13	2	13	63
9	Manure + N+P+S(A.P.16-20-0)	5660	109	684	15	55	13	40	404
11	Check	1022	16	100	3	10	2	16	62
	Breton Series B, 1944, Second Cutting.								
3	N+P+K+S(A.P.+P.S.,16-20-48)	2547	81	503	7	39	8	9	195
10	N+P+S(A.P.16-20-0)	2547	80	500	8	40	6	11	208
14	N+P(A.P.11-48-0)	272	6	40	1	6	1	2	22
15	N+P+S(S.Sp.2-19-0)	2547	76	475	6	37	6	8	187
21	S(Gyp.)	2547	82	514	7	40	5	2	180

Composition and Yield of First Year Clovers, Series C, 1945.

The crop grown on Series C consisted mainly of red clover and alfalfa. None of the series on the Breton field received fertilizer in 1945.

The residual effect of fertilizers upon the yields of the different plots has been very marked (Table IX). The lowest yield is below half a ton per acre and the highest is over three tons per acre. The maximum yield has been obtained from plot 15, receiving sulphur along with nitrogen and phosphorus (2-19-0).

A fairly large variation in the check plot yields occurs, indicating the initial fertility of the soil to be higher in the southern part of the series.

The use of lime has not had any beneficial effect upon the yield of clover. Its application along with phosphorus has produced a slight increase but the yield is still less than half a ton per acre.

Manure, applied alone, has produced a relatively small crop, being less than one ton in weight. Where manure is used along with ammonium phosphate (16-20-0), a great increase in yield has been obtained. The addition of the ammonium phosphate to the manure has evidently resulted in a considerable increase in crop response. The sulphur contained in this fertilizer may be responsible for the results obtained by its use.

Fertilization with materials containing nitrogen, either in combination with phosphorus, or alone, has produced some increase in yield over the checks but probably insufficient to warrant the use of such fertilizers. Similarly the use of phosphorus in any form not containing sulphur produces unsatisfactory yields on this series.

Table VIII. Yield and Percent Composition of First Year Clovers Grown on Gray Wooded Soil (Oven-dry basis).

Breton Series C, 1945, First Cutting.

Plot No.	Treatment	Yield lbs. per acre	% Nitrogen	% Protein	% Phosphorus	% Calcium	% Magnesium	% Silica	% Ash
1	Check	743	2.05	12.81	.29	1.46	.34	3.01	8.85
2	Manure	1879	2.00	12.50	.28	1.37	.33	2.54	8.98
3	N+P+K+S(A.P.+P.S.,16-20-48)	4967	2.36	14.75	.20	1.36	.33	.46	6.61
4	N+S(A.S.21-0-0)	4577	2.20	13.75	.18	1.75	.38	.51	6.84
5	Check	1029	1.75	10.94	.27	1.42	.27	2.43	7.76
6	Lime	841	1.84	11.50	.28	1.52	.28	2.31	7.97
7	Lime + P(T.Sp.0-43-0)	867	1.92	12.00	.28	1.54	.29	2.20	8.15
8	P(T.Sp.0-43-0)	1029	1.83	11.44	.29	1.51	.26	2.33	8.13
9	Manure +N+P+S(A.P.16-20-0)	5013	2.13	13.31	.25	1.54	.23	1.03	6.58
10	N+P+S(A.P.16-20-0)	4866	2.28	14.25	.21	2.00	.34	.60	7.06
11	Check	958	1.79	11.19	.26	1.41	.26	2.40	7.16
13	Check	1656	1.73	10.81	.27	1.19	.23	2.38	6.48
14	N+P(A.P.11-48-0)	1673	1.70	10.63	.27	1.17	.32	1.07	6.53
15	N+P+S(S.Sp.2-19-0)	5822	2.19	13.69	.20	1.61	.26	.22	7.11
16	P+S(S.Sp.0-20-0)	5053	2.18	13.63	.21	1.94	.39	.80	7.42
17	P(B.M.4-20-0)	1702	1.43	8.94	.25	1.09	.29	2.92	7.59
18	Check	1301	1.76	11.00	.26	1.37	.30	.96	6.47
19	N(A.N.34-0-0)	1564	1.72	10.75	.26	1.08	.29	1.43	6.18
20	Gyp.+N+S(A.N.34-0-0)	4356	2.16	13.50	.17	1.70	.33	.54	6.73
21	S(Gyp.)	4859	1.92	12.00	.17	1.50	.30	.45	6.50
22	Check	2340	1.64	10.25	.16	1.57	.32	.85	6.57
23	S(Sod.S.)	4592	2.12	13.25	.15	2.28	.37	.12	7.65
24	K+S(P.S.0-0-48)	5229	2.15	13.44	.15	1.99	.33	.53	8.12
25	N+K+S(P.S.+A.S.,21-0-48)	5099	2.27	14.19	.16	2.04	.33	.25	7.78
26	Check	2109	1.57	9.81	.24	1.33	.29	1.09	6.45

Table IX. Yield and Composition in Pounds Per Acre of First Year Clovers Grown on Gray Wooded Soil.

Breton Series C, 1945, First Cutting.

		Lbs. per acre							
Plot No.	Treatment	Yield (air-dry basis	Nitrogen	Protein	Phosphorus	Calcium	Magnesium	Silica	Ash
1	Check	782	15	95	2	11	3	22	66
2	Manure	1978	38	235	5	26	6	48	169
3	N+P+K+S(A.P.+P.S.,16-20-48)	5230	117	733	10	68	16	23	328
4	N+S(A.S.21-0-0)	4819	101	629	8	80	17	23	313
5	Check	1084	18	113	3	15	3	25	80
6	Lime	886	15	97	2	13	2	19	67
7	Lime +P(T.Sp.0-43-0)	913	17	104	2	13	3	19	71
8	P(T.Sp.0-43-0)	1084	19	118	3	16	3	24	84
9	Manure +N+P+S(A.P.16-20-0)	5278	107	667	13	77	12	52	330
10	N+P+S(A.P.16-20-0)	5124	111	693	10	97	17	29	344
11	Check	1009	17	107	2	14	2	23	69
13	Check	1744	29	179	4	20	4	39	107
14	N+P(A.P.11-48-0)	1762	28	178	5	20	5	18	109
15	N+P+S(S.Sp.2-19-0)	6130	128	797	12	94	15	13	414
16	P+S(S.Sp.0-20-0)	5321	110	689	11	98	20	40	375
17	P(B.M.4-20-0)	1792	24	152	4	19	5	50	129
18	Check	1370	23	143	3	18	4	12	84
19	N(A.N.34-0-0)	1647	27	168	4	17	5	22	97
20	Gyp.+N+S(A.N.34-0-0)	4587	94	588	7	74	14	24	293
21	S(Gyp.)	5116	93	583	8	73	15	22	316
22	Check	2464	38	240	4	37	7	20	154
23	S(Sod.S.)	4835	97	608	7	105	17	6	351
24	K+S(P.S.0-0-48)	5506	112	703	8	104	17	28	425
25	N+K+S(P.S.+A.S.,21-0-48)	5369	116	724	8	104	17	13	397
26	Check	2221	33	207	5	28	6	23	136

Table X. Percent Composition of First Year Clovers Grown on Gray Wooded Soil (Oven-dry basis). Data Grouped According to Yield or Treatment.

Breton Series C, 1945.

Plot Description	Plots Included	%N_2		% Prot.		%P		%Ca		%Mg		%SiO_2		% Ash	
		Rge.	Av.	Rge.	Ave.	Rge.	Av.	Rge.	Av.	Rge.	Av.	Rge.	Av.	Rge.	Av.
Checks	1,5,11,13, 18,22,26	1.57 2.05	1.76	9.81 12.81	10.97	.16 .29	.25	1.19 1.57	1.39	.23 .34	.29	.85 3.01	1.87	6.45 8.85	7.11
Low Yielders Rec. phos.	7,8,14,17	1.43 1.92	1.72	8.94 12.00	10.75	.25 .29	.27	1.09 1.54	1.33	.26 .32	.29	1.07 2.92	2.13	6.53 8.15	7.60
High Yielders Rec. phos.	3,9,10,15,16	2.13 2.36	2.23	13.31 14.75	13.93	.20 .25	.21	1.36 2.00	1.69	.23 .39	.31	.22 1.03	.62	6.58 7.42	6.96
All Plots Rec. phos.		1.43 2.36	2.00	8.94 14.75	12.52	.20 .29	.24	1.09 2.00	1.53	.23 .39	.30	.22 2.92	1.29	6.53 8.15	7.24
Plots Rec. manure	2,9	2.00 2.13	2.07	12.50 13.31	12.91	.25 .28	.27	1.37 1.54	1.46	.23 .33	.28	1.03 2.54	1.79	6.58 8.98	7.78
Sulphur with phos.	3,9,10,15,16	2.13 2.36	2.23	13.31 14.75	13.91	.20 .25	.21	1.36 2.00	1.69	.23 .39	.31	.22 1.03	.62	6.58 7.42	6.96
Sulphur without phos.	4,20,21,23, 24,25	1.92 2.27	2.14	12.00 14.19	13.36	.15 .18	.16	1.50 2.28	1.88	.30 .38	.34	.12 .54	.40	6.50 8.12	7.27
All Rec. sulphur		1.92 2.36	2.18	12.00 14.75	13.61	.15 .25	.19	1.36 2.28	1.79	.23 .39	.33	.12 1.03	.50	6.50 8.12	7.13

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Table X. cont'd.

Plot Description	Plots Included	%N2		% Prot.		%P		%Ca		%Mg		%SiO2		% Ash	
		Rge.	Av.	Rge.	Av.	Rge.	Av.	Rge.	Av.	Rge.	Av.	Rge.	Av.	Rge.	Av.
Nitrogen with phos.	3,9,10,14	1.70 2.36	2.12	10.63 14.75	13.24	.20 .27	.23	1.11 2.00	1.52	.23 .34	.31	.46 1.07	.79	6.53 7.06	6.70
Nitrogen without phos.	4,19,20,25	1.72 2.27	2.09	10.75 14.19	13.05	.16 .26	.19	1.08 2.04	1.64	.29 .38	.33	.25 1.43	.68	6.18 7.78	6.88
All Rec. nitrogen		1.70 2.36	2.10	10.63 14.75	13.14	.16 .27	.21	1.08 2.04	1.58	.23 .38	.32	.25 1.43	.74	6.18 7.78	6.79
High Yielders	3,4,9,10,15, 16,20,21,23, 24,25	1.92 2.36	2.17	12.00 14.75	13.61	.15 .25	.19	1.36 2.28	1.79	.23 .39	.33	.12 1.03	.50	6.50 8.12	7.13
Low Yielders	1,2,5,6,7,8, 11,13,14,17, 18,19,22,26	1.43 2.05	1.77	8.94 12.81	11.04	.16 .29	.26	1.08 1.57	1.36	.23 .34	.29	.85 3.01	1.99	6.18 8.98	7.37
All Fertilized Plots		1.43 2.36	2.02	8.94 14.75	12.64	.15 .29	.22	1.08 2.28	1.61	.23 .39	.31	.12 2.92	1.13	6.18 8.98	7.33
All Plots		1.43 2.36	1.95	8.94 14.75	12.17	.15 .29	.23	1.08 2.28	1.55	.23 .39	.31	.12 3.01	1.34	6.18 8.98	7.27

All fertilizers containing sulphur, whether applied alone or in conjunction with phosphorus or nitrogen, have produced significant yield increases. Sulphur appears to be the limiting element in the production of clovers on Series C. Yields through its use have risen to over two tons in all cases and to almost three tons per acre in several instances.

The Nitrogen and Protein Content.

The nitrogen content (Table VIII) on this series varies from 1.57 to 2.36 percent. The average nitrogen content over all the plots is 1.95 percent. Reliable sources ((32) and (28)) give the average content existing in red clover as between 2 and 2.1 percent. Some of these plots have produced crops slightly deficient in nitrogen in comparison with these data.

The amount of nitrogen per acre removed by the crop varies greatly with the different fertilizer applications on Series C. As a result, the lower yielding plots have removed as little as 15 pounds of nitrogen while the high yielders up to 128 pounds per acre.

The average nitrogen content of all fertilized plots is 2.02 percent (Table X) and the average for the checks is 1.76 percent. The effect of fertilizers in general has been to increase the nitrogen content of the crop.

The average nitrogen content of the high yielding plots is 2.17 percent and for the low yielders is only 1.77 percent. Apparently those treatments tending to increase the crop yield also encourage a higher nitrogen level.

Crops from the low yielding plots receiving phosphorus have a low nitrogen content as compared to the average of all fertilized plots. The high yielders receiving phosphorus have a higher content of nitrogen than the average. The average percent nitrogen for all plots receiving phosphorus is somewhat higher than for the checks and about the same as the average for all fertilized plots.

The effect of manure applied alone or along with ammonium phosphate (16-20-0) has been to increase the nitrogen content of the clovers.

Those crops receiving both sulphur and phosphorus show an average nitrogen content equally as high as for any other treatment and considerably higher than the average for all the fertilized plots. The application of sulphur without phosphorus has produced an increased nitrogen content in the crop, although not quite so marked as where these two elements have been used in combination.

Crops treated with nitrogenous fertilizers, either with or without phosphorus, contain slightly more nitrogen than is present in the average of all plots receiving fertilizer.

The Phosphorus Content.

The phosphorus content of the clovers from this series varies quite greatly. The lowest content, from plots 23 and 24, is .15 percent and the highest content, as obtained from plots 1 and 8, is .29 percent. The highest percentage of phosphorus is present in the plots receiving triple super phosphate and the number 1 check and the lowest is found in those receiving either sodium or potassium sulphate. The average percentage over all

the plots is .23. The average percentage of phosphorus in red clover as given by Henry and Morrison (28) is .17 and by Hopkins (32) is .25, so that these crops appear to contain normal amounts of this element. A few of the plots are fairly low in phosphorus, approaching the lower normal limits in this respect.

In some instances, as in several of the check plots and in those plots receiving lime with and without triple super phosphate (0-43-0), the crops have removed as little as 2 pounds of phosphorus per acre. Of the higher yielders, plot 15, receiving single super phosphate (2-19-0) has removed 12 pounds of phosphorus and plot 9 receiving manure plus ammonium phosphate (16-20-0) has removed 13 pounds per acre.

The high yielding plots show an average phosphorus content of .19 percent. On the other hand the low yielders contain an average of .26 percent. These data would indicate that the higher yields result in a lower phosphorus content and more economical use of this element by the crop. The average phosphorus content of all the crops receiving fertilizers is .22 percent. Comparing this figure to .25 percent as the average of the checks, it is apparent that the fertilizers in general have not affected the phosphorus content of the crop significantly.

The average phosphorus content of all the crops receiving phosphatic fertilizers is .24 percent, whereas the average for the checks is .25 percent. Such fertilizers have not apparently affected the phosphorus content of the crop. The low yielding plots receiving phosphorus are slightly higher in this constituent than are the high yielders.

The two plots receiving manure have produced crops containing average amounts of phosphorus very similar to the checks.

The average phosphorus content of crops grown on plots receiving both sulphur and phosphorus is .05 percent higher than where sulphur is applied without phosphorus. The overall effect of sulphur application has been to decrease the phosphorus content, this decrease being smaller where phosphorus has also been applied. Since similar results have usually occurred wherever an increase in yield has been obtained, this may be due more to the larger yield than to any direct effect of the sulphur.

Plots receiving nitrogen with and without phosphorus have produced crops with lower percentages of phosphorus than the checks. Since most of these nitrogenous fertilizers also contain sulphur, their use has resulted in increased yields and decreased phosphorus contents.

The Calcium Content.

The content of calcium found in the clovers from Series C varies from 1.08 to 2.28 percent. The average content for the complete series is 1.55 percent. Compared to values quoted by Henry and Morrison (28) and Wolff (55), these crops contain normal amounts of calcium.

Some of the higher yielding plots have removed up to 105 pounds of calcium per acre and the lowest amount is 11 pounds per acre. The plots receiving sodium sulphate, potassium sulphate, or potassium sulphate plus ammonium sulphate have removed the largest quantities of calcium. Plots 10, 15 and 16 have also removed appreciable amounts of this element.

The average calcium content for the high yielding plots is 1.79 percent, .40 percent more than the checks. The percentage of calcium in the low yielding plots is about the same as the checks. Increased yield in this case has resulted in higher calcium content of the crop.

The average of the fertilized crops shows their calcium content to be 1.61 percent, .22 percent higher than the average of the checks. The fertilizers in general have caused an increase in the calcium content of clovers on this series.

No effect of lime, or fertilizers containing calcium, upon the calcium content of the crop is apparent. Many of the crops receiving such fertilizers are fairly rich in calcium but some of the plots treated otherwise show equally as high calcium contents. This soil appears to be quite well supplied with available calcium.

The Magnesium Content.

The lowest amount of magnesium found in these clovers is .23 percent. The highest amount is .39 percent. The crops from plot 16, receiving single superphosphate (0-20-0) and plot 4, treated with ammonium sulphate, have the highest magnesium contents. The average content of this element over the entire series is .31 percent. These crops are quite well supplied with magnesium, containing .04 percent in excess of the average given by Henry and Morrison (28).

The smallest amount of magnesium removed by the clover crop is 2 pounds per acre and the largest amount, removed by plot 16, is 20 pounds.

The average percentage of magnesium from the high yielding plots is .33 and from the low yielders is .29. The

average content over all the fertilized plots is .31 percent, while the average of the checks is .29 percent. The magnesium content does not appear to have been appreciably affected either by the yield of crop produced or the use of fertilizers in general.

The average magnesium contents as a result of different specific fertilizer treatments on this series do not differ very much from the average of the checks, those fertilizers containing sulphur without phosphorus causing a slight increase in magnesium content.

The Silica Content.

The percentage of silica found in these clovers varies from .12 to 3.01 with at least half of the plots containing over 1 percent. The average content of all plots is 1.34 percent. Reference to data given by Wolff (55) and Henry and Morrison (28) indicates that the crops from most of these plots are high in this compound. The presence of other plants such as grasses, which are fairly high in silica, growing with the clovers may help to account for these differences.

The average silica content for all the fertilized plots is .74 percent lower than the average of the checks. The effect of fertilizer in general has been to decrease the silica content of the plants.

The higher yielding plots contain an average of .50 percent silica and the lower yielders 1.99 percent. Those treatments tending towards higher crop yields are apparently effective in lowering the silica content of the hay produced.

The Ash Content.

The amount of ash present in the clovers from this series ranges from 6.18 to 8.98 percent, the average content throughout the series being 7.27 percent. Wolff (55) and Henry and Morrison (28) place the average content of red clovers between 6.9 and 7.4 percent. This crop contains average amounts of non-combustible matter in comparison to these figures.

Crops from the high yielding plots contain .24 percent less ash than from the low yielders.

The average of all fertilized plots is 7.33 percent ash and the checks is 7.11 percent. Evidently the fertilizers in general have tended to slightly increase the ash content of these clovers.

Composition and Yield of Barley Green Feeds, 1945.

Series D and F were seeded to Olli barley on June 1st and sampled as green feed on July 27th. The east half of Series E was planted to Titan barley on May 14th and sampled July 17th.

When comparing the data (Tables XI and XII), it must be considered that samples from plots similarly fertilized have not in all cases been available for analysis. The varietal differences may also affect these comparisons somewhat.

Quite large variations in yield are evident as a result of the different treatments. The lowest yielding plot has produced slightly over one quarter ton and the highest yielder close to two tons of hay per acre. The average yield of Titan barley grown after fallow is largest and the smallest average yield is obtained where Olli barley is nursing clovers. These barley green feeds have produced slightly over three quarters of a ton of hay per acre on an average.

The average nitrogen content of the hay is 1.72 percent. Henry and Morrison (28) state that 1.12 percent nitrogen is an average amount for this type of crop so that these hays are considerably above average in this respect. The effect of clovers, plowed under two seasons previous to the Olli barley on Series F, has been to produce a crop with an average nitrogen content of 2.05 percent. The Olli barley nursing clovers, grown on the land three seasons after clovers have been plowed under, has an average nitrogen content of 1.68 percent. On Series E where no clovers are grown, the nitrogen content is only 1.45 percent. As much as 66 pounds of nitrogen have been removed in the higher yielding crops, the lower yielders removing as little as 10 pounds per acre.

An average phosphorus content of .30 percent has been found in the barley hay. The Titan barley after fallow contains the lowest average amount of phosphorus, .26 percent, and the average of the other two series is about .33 percent. These hays are apparently richer in phosphorus than clovers and alfalfa grown on similar soil. The amount of phosphorus removed per acre is 12 pounds from the highest yielding plot and 2 pounds from one of the lowest yielders.

The magnesium content from the different plots varies from .14 to .24 percent, the majority of them falling between the limits of .17 and .22 percent. The average content over the three series is .19 percent. Little variation in the magnesium content of the hay is evident as a result of the different plot treatments. Only one pound of magnesium per acre has been removed from several of the check plots, the higher yielding plots removing up to 8 pounds per acre.

The average silica content over the three series is 1.94 percent, considerably higher than that found in the legumes. The highest yielding series has produced the crop with the lowest average amount of silica. Series B, the lowest yielder, contains the highest percentage of this constituent.

These hays appear to be somewhat above normal in their average content of ash. Henry and Morrison (28) give the average amount found in barley hays as 6.4 percent. The average over these three series is 6.97 percent, the amount varying from a minimum of 4.83 to a maximum of 8.98 percent. The ash content of the Titan barley after fallow is considerably lower than for the Olli barley on the other series.

Table XI. Yield and Percent Composition of Barley Green Feed Grown on Gray Wooded Soil (Oven-dry basis).

Breton Series D, 1945, Olli Barley With Clovers.

Plot No.	Treatment	Yield lbs. per acre	% Nitrogen	% Protein	% Phosphorus	% Calcium	% Magnesium	% Silica	% Ash
3	N+P+K+S(A.P.+P.S.,16-20-48)	1769	1.44	9.00	.26	.35	.19	1.30	5.66
4	N+S(A.S.21-0-0)	1318	1.62	10.13	.25	.43	.18	1.32	5.69
5	Check	741	1.61	10.06	.38	.50	.19	1.90	6.68
9	Manure +N+P+S(A.P.16-20-0)	2284	1.81	11.31	.28	.38	.16	1.27	6.82
10	N+P+S(A.P.16-20-0)	1330	1.54	9.63	.30	.46	.22	2.38	7.56
11	Check	765	1.62	10.13	.40	.47	.22	2.50	8.19
14	N+P(A.P.11-48-0)	1016	1.76	11.00	.38	.53	.24	3.18	8.76
15	N+P+S(S.Sp.2-19=0)	1029	1.87	11.69	.31	.52	.21	1.72	7.72
18	Check	816	1.87	11.69	.36	.53	.22	2.92	8.98
21	S(Gyp.)	1192	1.64	10.25	.23	.44	.20	3.17	8.21
	Breton Series E, 1945, Titan Barley After Fallow.								
4	N+S(A.S.21-0-0)	1129	1.17	7.31	.24	.29	.14	1.84	5.16
5	Check	939	1.11	6.94	.24	.27	.13	1.73	4.83
9	Manure +N+P+S(A.P.16-20-0)	3768	1.62	10.13	.33	.46	.20	1.80	7.40
11	Check	2309	1.26	7.88	.26	.31	.17	1.57	5.26
13	Check	1878	1.72	10.75	.24	.38	.17	1.23	5.33
18	Check	2752	1.57	9.81	.24	.35	.20	1.86	6.15
24	K+S(P.S.0-0-48)	2487	1.73	10.81	.26	.41	.22	1.98	6.72
	Breton Series F, 1945, Olli Barley After Wheat Following Clovers.								
4	N+S(A.S.21-0-0)	2311	1.97	12.31	.23	.50	.20	.98	6.62
5	Check	796	2.27	14.19	.40	.51	.19	1.71	6.91
9	Manure +N+P+S(A.P.16-20-0)	3536	1.87	11.69	.30	.52	.19	1.14	7.96
11	Check	909	2.47	15.44	.44	.56	.20	2.20	7.59
15	N+P+S(S.Sp.2-19-0)	2841	1.65	10.31	.24	.47	.18	1.32	6.32
18	Check	770	2.43	15.19	.39	.56	.20	3.12	8.84
21	S(Gyp.)	1969	1.67	10.44	.28	.60	.18	2.32	7.86

Table XII. Yield and Composition in Pounds per Acre of Barley Green Feed Grown on Gray Wooded Soil.

Breton Series D, 1945, Olli Barley With Clovers.

		Lbs. per acre							
Plot No.	Treatment	Yield (air-dry basis)	Nitrogen	Protein	Phosphorus	Calcium	Magnesium	Silica	Ash
3	N+P+K+S(A.P.+P.S.,16-20-48)	1882	25	159	5	6	3	23	100
4	N+S(A.S.21-0-0)	1402	21	134	3	6	2	17	75
5	Check	788	12	75	3	4	1	14	49
9	Manure +N+P+S(A.P.16-20-0)	2430	41	258	6	9	4	29	156
10	N+P+S(A.P.16-20-0)	1415	20	128	4	6	3	32	101
11	Check	814	12	77	3	4	2	19	63
14	N+P(A.P.11-48-0)	1081	18	112	4	5	2	32	89
15	N+P+S(S.Sp.2-19-0)	1095	19	120	3	5	2	18	79
18	Check	868	15	95	3	4	2	24	73
21	S(Gyp.)	1268	20	122	3	5	2	38	98

Breton Series E, 1945, Titan Barley After Fallow.

Plot No.	Treatment	Yield (air-dry basis)	Nitrogen	Protein	Phosphorus	Calcium	Magnesium	Silica	Ash
4	N+S(A.S.21-0-0)	1188	13	83	3	3	2	21	58
5	Check	988	10	65	2	3	1	16	45
9	Manure +N+P+S(A.P.16-20-0)	3965	61	382	12	17	8	68	279
11	Check	2430	29	182	6	7	4	36	121
13	Check	1976	32	202	5	7	3	23	100
18	Check	2896	43	270	7	10	6	51	169
24	K+S(P.S.0-0-48)	2617	43	269	6	10	5	49	167

Breton Series F, 1945, Olli Barley After Wheat Following Clovers.

Plot No.	Treatment	Yield (air-dry basis)	Nitrogen	Protein	Phosphorus	Calcium	Magnesium	Silica	Ash
4	N+S(A.S.21-0-0)	2443	46	284	5	12	5	23	153
5	Check	841	18	113	3	4	2	14	55
9	Manure +N+P+S(A.P.16-20-0)	3738	66	413	11	18	7	40	281
11	Check	961	22	140	4	5	2	20	69
15	N+P+S(S.Sp.2-19-0)	3003	47	293	7	13	5	38	180
18	Check	814	19	117	3	4	2	24	68
21	S(Gyp.)	2082	33	206	6	12	4	46	155

Composition and Yield of Second Year Clovers, Series C, 1946.

The yield of hay, consisting of a mixture of alfalfa and Altaswede clover, is somewhat lower than for the series previously discussed. A minimum of about one quarter ton and a maximum of two and a half tons per acre have been produced on this series (Table XIV). The highest yielding plots are plots 23, receiving sodium sulphate, 20 receiving ammonium nitrate and gypsum, and 21, which receives gypsum. Although the checks in the southern half of the series have produced larger yields than in the northern half, the effect of the fertilizers is still very marked.

Lime applied alone has had no beneficial effect upon the yield, but when used in conjunction with triple super phosphate (0-43-0), a slight yield increase has been produced.

Manure applied alone has produced a crop of over one ton per acre and when applied along with ammonium phosphate (16-20-0) has resulted in a greater crop response and a yield of almost two and a half tons per acre. The sulphur content of this chemical fertilizer may at least in part be responsible for the increased yield obtained by its use.

Some increases have been obtained through the application of fertilizers containing one or both of nitrogen and phosphorus. By far the greatest response has occurred where sulphur is applied. The effect of the sulphur has been to greatly increase the yield when used alone or in combination with other elements. The yields have been equally as good and in some cases better where neither nitrogen nor phosphorus were applied in conjunction with the sulphur.

Table XIII. Yield and Percent Composition of Second Year Clovers Grown on Gray Wooded Soil (Oven-dry basis).

Breton, Series C, 1946, First Cutting.

Plot No.	Treatment	Yield lbs. per acre	% Nitrogen	% Protein	% Phosphorus	% Calcium	% Magnesium	% Silica	% Ash
1	Check	561	2.34	14.63	.37	1.35	.30	1.47	10.20
2	Manure	2154	2.13	13.31	.32	1.15	.29	1.14	9.87
3	N+P+K+S(A.P.+P.S.,16-20-48)	3315	2.93	18.31	.27	1.89	.41	.62	11.46
4	N+S(A.S.21-0-0)	4255	2.68	16.75	.21	2.08	.40	.34	11.22
5	Check	498	2.45	15.31	.35	1.56	.36	3.14	12.20
6	Lime	501	2.18	13.63	.33	1.48	.32	5.61	14.17
7	Lime + P(T.Sp.0-43-0)	1057	2.29	14.31	.31	1.77	.35	1.59	10.95
8	P(T.Sp.0-43-0)	1002	2.45	15.31	.32	1.62	.33	.80	10.18
9	Manure +N+P+S(A.P.16-20-0)	4631	2.99	18.69	.35	1.51	.25	.43	11.65
10	N+P+S(A.P.16-20-0)	4240	2.86	17.88	.25	2.60	.33	.28	12.22
11	Check	501	2.45	15.31	.36	1.75	.35	.94	10.34
13	Check	728	2.08	13.00	.32	1.34	.28	1.30	8.95
14	N+P(A.P.11-48-0)	2228	2.43	15.19	.34	1.63	.33	.29	10.26
15	N+P+S(S.Sp.2-19-0)	4446	2.87	17.94	.27	1.89	.26	.28	11.30
16	P+S(S.Sp.0-20-0)	4120	2.82	17.63	.25	2.18	.31	.56	11.94
17	P(B.M.4-20-0)	1184	2.28	14.25	.33	1.49	.31	.67	9.34
18	Check	848	2.13	13.31	.30	1.40	.29	1.26	9.18
19	N(A.N.34-0-0)	1369	1.93	12.06	.27	1.12	.25	1.38	8.37
20	Gyp.+N+S(A.N.34-0-0)	4933	3.07	19.19	.22	2.25	.28	.23	11.37
21	S.(Gyp.)	4748	2.81	17.56	.20	2.58	.37	.35	12.21
22	Check	1578	2.14	13.38	.22	1.71	.30	1.16	9.88
23	S(Sod.S.)	5057	2.83	17.69	.18	2.59	.33	.35	12.30
24	K+S(P.S.0-0-48)	4571	2.84	17.75	.19	2.24	.30	.30	11.44
25	N+K+S(P.S.+A.S.21-0-48)	3821	-	-	.21	2.55	.31	.27	12.61
26	Check	1206	2.36	14.75	.32	1.74	.33	.76	10.67

Table XIV. Yield and Composition in Pounds Per Acre of Second Year Clovers Grown on Gray Wooded Soil.

Breton Series C, 1946, First Cutting.

Plot No.	Treatment	Yield (air-dry basis)	Nitrogen	Protein	Phosphorus	Calcium	Magnesium	Silica	Ash
		Lbs. per acre							
1	Check	601	13	82	2	8	2	8	57
2	Manure	2307	46	287	7	25	6	25	213
3	N+P+K+S(A.P.+P.S.,16-20-48)	3551	97	607	9	63	14	21	380
4	N+S(A.S.21-0-0)	4558	114	713	9	89	17	14	477
5	Check	534	12	76	2	8	2	16	61
6	Lime	537	11	68	2	7	2	28	71
7	Lime +P(T.Sp.0-43-0)	1132	24	151	3	19	4	17	116
8	P(T.Sp.0-43-0)	1073	25	153	3	16	3	8	102
9	Manure +N+P+S(A.P.16-20-0)	4961	138	866	16	70	12	20	540
10	N+P+S(A.P.16-20-0)	4542	121	758	11	110	14	12	518
11	Check	537	12	77	2	9	2	5	52
13	Check	780	15	95	2	10	2	9	65
14	N+P(A.P.11-48-0)	2387	54	338	8	36	7	6	229
15	N+P+S(S.Sp.2-19-0)	4763	128	798	12	84	12	12	502
16	P+S(S.Sp.0-20-0)	4414	116	726	10	90	13	23	492
17	P(B.M.4-20-0)	1268	27	169	4	18	4	8	111
18	Check	908	18	113	3	12	2	11	78
19	N(A.N.34-0-0)	1466	26	165	4	15	3	19	115
20	Gyp.+N+S(A.N.34-0-0)	5284	151	947	11	111	14	11	561
21	S(Gyp.)	5086	133	834	9	122	18	17	580
22	Check	1690	34	211	3	27	5	18	156
23	S(Sod.S.)	5417	143	895	9	131	17	18	622
24	K+S(P.S.0-0-48)	4897	130	811	9	102	14	14	523
25	N+K+S(P.S.+A.S.,21-0-48)	4093	-	-	8	97	12	10	482
26	Check	1292	28	178	4	21	4	9	129

Table XV. Percent Composition of Second Year Clovers Grown on Gray Wooded Soil (Oven-dry basis).

Data Grouped According to Yield or Treatment.
Breton Series C, 1946.

Plot Description	Plots Included	%N2		% Prot.		%P		%Ca		%Mg		%SiO2		% Ash	
		Rge.	Av.	Rge.	Av.	Rge.	Av.	Rge.	Av.	Rge.	Av.	Rge.	Av.	Rge.	Av.
Checks	1,5,11,13,18, 22,26	2.08 2.45	2.28	13.00 15.31	14.24	.22 .37	.32	1.34 1.75	1.55	.28 .36	.32	.76 3.14	1.43	8.95 12.20	10.20
Low Yielders Rec. phos.	7,8,14,17	2.28 2.45	2.36	14.25 15.31	14.97	.31 .34	.33	1.49 1.77	1.63	.31 .35	.33	.29 1.59	.84	9.34 10.95	10.18
High Yielders Rec. phos.	3,9,10,15,16	2.82 2.99	2.89	17.63 18.69	18.09	.25 .35	.28	1.51 2.60	2.01	.25 .41	.31	.28 .62	.43	11.30 12.22	11.71
All Plots Rec. phos.		2.28 2.99	2.66	14.25 18.69	16.70	.25 .35	.30	1.49 2.60	1.84	.25 .41	.32	.28 1.59	.61	9.34 12.22	11.04
Plots Rec. manure	2,9	2.13 2.99	2.56	13.31 18.69	16.00	.32 .35	.34	1.15 1.51	1.33	.25 .29	.27	.43 1.14	.79	9.87 11.65	10.76
Sulphur with phos.	3,9,10,15,16	2.82 2.99	2.89	17.63 18.69	18.09	.25 .35	.28	1.51 2.60	2.01	.25 .41	.31	.28 .62	.43	11.30 12.22	11.71
Sulphur without phos.	4,20,21,23, 24,25	2.68 3.07	2.85	16.75 19.19	17.79	.18 .22	.20	2.08 2.59	2.38	.28 .40	.33	.23 .35	.31	11.22 12.61	11.86
All Rec. sulphur		2.68 3.07	2.87	16.75 19.19	17.94	.18 .35	.24	1.51 2.60	2.21	.25 .41	.32	.23 .62	.36	11.22 12.61	11.79

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Table XV. cont'd.

Plot Description	Plots Included	$\%N_2$		% Prot.		%P		%Ca		%Mg		$\%SiO_2$		% Ash	
		Rge.	Av.	Rge.	Av.	Rge.	Av.	Rge.	Av.	Rge.	Av.	Rge.	Av.	Rge.	Av.
Nitrogen with phos.	3,9,10,14	2.43 2.99	2.80	15.19 18.69	17.52	.25 .35	.30	1.51 2.60	1.91	.25 .41	.33	.28 .62	.41	10.26 12.22	11.40
Nitrogen without phos.	4,19,20,25	1.93 3.07	2.56	12.06 19.19	16.00	.21 .27	.23	1.12 2.55	2.00	.25 .40	.31	.23 1.38	.55	8.37 12.61	10.89
All Rec. nitrogen		1.93 3.07	2.70	12.06 19.19	16.87	.21 .35	.27	1.12 2.60	1.95	.25 .41	.32	.23 1.38	.48	8.37 12.61	11.15
High Yielders	4,9,10,15,16,20,21,23,24,25	2.68 3.07	2.86	16.75 19.19	17.90	.18 .35	.23	1.51 2.60	2.25	.25 .40	.31	.23 .56	.34	11.22 12.30	11.83
Low Yielders	1,2,3,5,6,7,8,11,13,14,17,18,19,22,26	1.93 2.93	2.31	12.06 18.31	14.40	.22 .37	.32	1.12 1.89	1.53	.25 .41	.32	.29 3.14	1.18	8.37 14.17	10.40
All Fertilized Plots		1.93 3.07	2.61	12.06 19.19	16.32	.18 .35	.27	1.12 2.60	1.92	.25 .41	.32	.23 1.59	.58	8.37 14.17	11.27
All Plots		1.93 3.07	2.51	12.06 19.19	15.71	.18 .37	.28	1.12 2.60	1.82	.25 .41	.32	.23 3.14	.83	8.37 14.17	10.97

The Nitrogen and Protein Content.

The nitrogen content from Series C (Table XIII) varies from 1.93 to 3.07 percent with an average of 2.51 percent. This crop is quite rich in this element, plot 19, receiving ammonium nitrate, being the only one below the average as given by Henry and Morrison (28) and Hopkins (32).

Nitrogen has been removed at the rate of 151 pounds per acre from plot 20, treated with gypsum plus ammonium nitrate and 143 pounds per acre from the sodium sulphate plot (Table XIV). On the other hand, the limed plot and one of the checks have removed only 11 and 12 pounds per acre respectively.

The average content of nitrogen of all the check plots is 2.28 percent (Table XV). When this is compared to an average of 2.61 percent for the fertilized plots, it can be concluded that the general effect of fertilizers on this series has been to increase the nitrogen content of the crop.

Apparently those fertilizer treatments tending to increase the yield also encourage a higher nitrogen content of the crop. The average content of the high yielding plots is 2.86 percent, .55 percent higher than the average for the low yielders.

The high yielding crops receiving phosphorus have a considerably higher nitrogen content than the average for all the fertilized crops. The low yielders similarly treated contain comparable amounts of nitrogen to the checks, but less than the average of all the fertilized plots by .25 percent. The average content of this element in all the plots receiving phosphorus is very similar to the average of all fertilized plots.

The effect of the ammonium phosphate has been to increase the nitrogen content by .83 percent over the plot receiving manure alone and .71 percent over the average of the checks.

The including of phosphorus in fertilizers containing sulphur has not had any appreciable effect upon the nitrogen content of the clovers, the average being 2.85 percent where used in the absence of phosphorus and 2.89 percent when applied with phosphorus. The average of all crops receiving sulphur is 2.87 percent nitrogen - considerably higher than the average of the check plots and higher than the average of all fertilized plots by .26 percent.

The average nitrogen content of all plots receiving nitrogenous fertilizers is slightly higher than for all plots fertilized. Those plots receiving both nitrogen and phosphorus have a somewhat higher nitrogen content than those treated with nitrogen in the absence of phosphorus.

The Phosphorus Content.

The phosphorus content of the second year clovers on Series C ranges from .18 to .37 percent. The average throughout the entire series is .28 percent. Plot 1, a check plot, contains the highest percentage and plot 23, treated with sodium sulphate, has the lowest amount of this element. Check plots 5 and 11 and plot 14, receiving ammonium phosphate, (11-48-0), are also high in phosphorus. The average percentage in red clovers given by Hopkins (32) is .25 and by Henry and Morrison (28) is .17. These plots are relatively high in this constituent, all being above the amounts cited by these authorities.

Plot 9, receiving manure plus ammonium phosphate (16-20-0) has removed 16 pounds of phosphorus per acre, while several of the checks and the limed plot have removed only 2 pounds per acre.

The high yielding plots in this series contain .23 percent phosphorus, which is .09 percent less than the average for the low yielders and .04 percent less than the average of all fertilized plots. The high yields apparently result in a lower phosphorus content of the crop on this series. The average amount of phosphorus in the crop from all the fertilized plots is .27 percent. Comparing this to an average of .32 percent for the checks, it appears that the effect of the fertilizer has been to slightly decrease the phosphorus content.

The average phosphorus content of the plots receiving phosphatic fertilizers is .30 percent and the average of all fertilized plots is .27 percent. The effect of the phosphatic fertilizers has been to decrease the phosphorus content of the crop to about the same extent as fertilizers in general. The low yielders receiving phosphorus contain similar amounts of this element to the checks and .05 percent more than the high yielders receiving similar treatment in this respect.

The phosphorus content of the manured plot is similar to the checks and where ammonium phosphate (16-20-0) has been applied with the manure a very slight increase in this constituent has resulted.

Those plots receiving both sulphur and phosphorus contain .08 percent more phosphorus than do those treated with sulphur in the absence of phosphorus. Although the general effect

of the sulphur application has been to decrease the phosphorus content, the latter reduction has been small when the combined fertilizer containing both sulphur and phosphorus is used.

The average phosphorus content of all plots receiving nitrogen is .27 percent, the same as the average of all fertilized plots, or .05 percent lower than the average of the checks. Those plots receiving phosphorus with nitrogen have had their phosphorus content maintained more successfully than where nitrogen was applied in the absence of phosphorus.

The Calcium Content.

Many of the plots in this series are quite high in calcium, the highest being plot 10 with 2.60 percent. Seven other plots also contain over 2 percent of this element. Plot 19, treated with ammonium nitrate, contains 1.12 percent, the smallest amount found in this series. The average calcium content for the entire series is 1.82 percent. Compared to the values of 1.14 percent by Henry and Morrison (28) and 1.70 percent by Wolff (55), these clovers are above average in calcium content.

Amounts of calcium up to 131 pounds per acre have been removed and many of the plots have removed more than 75 pounds per acre. The smallest amount, 7 pounds per acre, was removed by the limed plot.

Crops from the high yielding plots show an average calcium content of 2.25 percent as compared to 1.53 percent for the low yielders. It is suggested that those factors tending to increase the yield also tend towards higher calcium contents. The percentage of calcium in the low yielding plots is similar to that of the checks The general effect of fertilizer has

been to produce a crop containing 1.92 percent calcium or about .39 percent more than is present in the checks.

The crops receiving sulphur and phosphorus contain smaller amounts of calcium than do those fertilized with sulphur in the absence of phosphorus.

Some of the crops receiving calcium contain fairly large amounts of this element while others do not. The calcium content of the crop has not apparently been affected either by the presence or absence of calcium in the applied fertilizer.

The Magnesium Content.

The magnesium content varies from .25 to .41 percent. The majority of the plots contain between .28 and .35 percent and the average of all the plots is .32 percent. This clover is quite well supplied with magnesium, plots 9, 15 and 19 being the only ones containing less than the amount given as average by Henry and Morrison (28). Those plots receiving potassium sulphate plus ammonium phosphate (16-20-0) and ammonium sulphate contain the largest percentages of magnesium.

The smallest amount of magnesium removed in the crop is 2 pounds per acre and the largest amount is 18 pounds, about half of the plots removing more than 10 pounds per acre.

No difference is apparent between the magnesium content of the low and high yielding plots, the low yielders containing .31 and the high yielders .32 percent.

The average of all fertilized plots is the same as the average of the checks. The fertilizers in general have apparently not affected the magnesium content of these clovers.

The manured plots show a slightly lower magnesium content than the checks. The application of other types of fertilizers, either alone or in combination, has not appreciably affected the magnesium content of the crop.

The Silica Content.

The average percentage of silica found in the clovers from Series C is .83, the amounts ranging from .23 to 3.14 percent.* Comparison with data from reliable sources ((28) and (55)) shows that these clovers are high in silica.

The check plots contain an average of 1.43 percent silica or about .85 percent more than is present in the crops receiving fertilizers in general. The effect of the fertilizer has been to decrease the silica content of the plant.

The high yielding crops contain considerably less silica than is found in the low yielders. The effect of the fertilizers in decreasing the silica content may be due more to the subsequent increased yields produced than to any direct effect upon the uptake of silica by the plant.

The Ash Content.

The percentage of ash is higher than in the two preceding series. The maximum amount is 14.17 and the minimum is 8.37 percent, the average of all plots being 10.97 percent. This crop contains relatively large amounts of ash in comparison to the data given by Henry and Morrison (28) and Wolff (55).

The high yielding plots contain a greater amount of ash than the low yielders. The effect of fertilizers has been to increase the ash content of the crop. The average for all the fertilized plots is 11.27 percent, or 1.07 percent higher than the

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* next page.

average of the checks.

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*The silica result from plot 6 has been discarded as possible contamination of the sample is suggested.

Composition and Yield of First Year Clovers, Series D, 1946.

The crop from this series consists of a mixture of Altaswede clover and alfalfa. The yields, (Table XVII) are not as high in general as obtained for similar crops in 1944 or 1945. Many of the plots have produced from one to one and a half tons, and the highest yielder nearly three tons per acre. The number 1 check plot has produced slightly over 1/4 ton, the lowest yield in the series. The application of potassium sulphate plus ammonium phosphate (16-20-0) to plot 3 has resulted in the production of close to 3 tons of hay per acre, more than 3/4 ton in excess of plot 15, the second highest yielder.

Differences in check plot yields indicate considerable variation in the initial fertility of the soil.

Lime, applied alone to plot 6, has produced a yield increase over the two checks nearest it, and when applied along with triple superphosphate (0-43-0) a further yield increase has resulted.

A crop of over 2 tons per acre has been produced on plot 9 with the combined use of manure and ammonium phosphate (16-20-0). Manure applied alone has produced slightly over 1 ton of hay per acre.

The highest yielding plots are those receiving sulphur, either alone or in conjunction with nitrogen and phosphorus. The latter two elements applied in the absence of sulphur have produced slight yield increases over the checks, but not so great as where sulphur has also been included.

Table XVI. Yield and Percent Composition of First Year Clovers Grown on Gray Wooded Soil (Oven-dry basis).

Breton Series D, 1946, First Cutting.

Plot No.	Treatment	Yield lbs. per acre	% Nitrogen	% Protein	% Phosphorus	% Calcium	% Magnesium	% Silica	% Ash
1	Check	475	2.64	16.50	.21	2.24	.43	.73	12.24
2	Manure	1978	2.21	13.81	.25	1.65	.34	2.39	11.90
3	N+P+K+S(A.P.+P.S.,16-20-48)	5490	2.47	15.44	.31	1.95	.38	.90	11.68
4	N+S(A.S.21-0-0)	3450	2.90	18.13	.21	2.53	.42	.56	12.39
6	Lime	963	2.26	14.13	.26	2.04	.32	3.18	12.57
7	Lime +P(T.Sp.0-43-0)	1595	2.56	16.00	.31	2.28	.41	1.50	12.58
8	P(T.Sp.0-43-0)	1380	2.53	15.81	.30	2.03	.36	.75	11.54
9	Manure +N+P+S(A.P.16-20-0)	3762	2.86	17.88	.31	1.78	.34	.47	11.82
10	N+P+S(A.P.16-20-0)	3551	2.78	17.38	.23	2.26	.40	.48	9.57
11	Check	809	2.52	15.75	.32	2.12	.36	1.75	10.32
14	N+P(A.P.11-48-0)	2247	2.56	16.00	.30	2.07	.32	.50	9.48
15	N+P+S(S.Sp.2-19-0)	3929	2.94	18.38	.28	2.37	.43	.43	11.33
16	P+S(S.Sp.0-20-0)	3808	2.99	18.69	.25	2.37	.44	.82	11.21
17	P(B.M.4-20-0)	1453	2.04	12.75	.32	1.58	.27	1.02	7.43
18	Check	1186	1.97	12.31	.26	1.61	.32	1.51	8.13
19	N(A.N.34-0-0)	1328	2.46	15.38	.25	1.96	.37	.97	9.26
20	Gyp.+N+S(A.N.34-0-0)	2973	2.51	15.69	.20	2.42	.39	1.01	10.02
21	S(Gyp.)	3137	2.77	17.31	.20	3.15	.45	.62	9.81
23	S(Sod.S.)	2757	3.06	19.13	.21	2.52	.40	.78	11.47
24	K+S(P.S.0-0-48)	2461	3.14	19.63	.26	2.06	.34	.43	10.29
25	N+K+S(P.S.+A.S.,21-0-48)	2598	2.73	17.06	.21	2.77	.42	.40	11.11
26	Check	1683	2.61	16.31	.20	2.37	.38	.57	11.38

Table XVII. Yield and Composition in Pounds per Acre of First Year Clovers Grown on Gray Wooded Soil.

Breton Series D, 1946, First Cutting.

		Lbs. per acre							
Plot No.	Treatment	Yield (air-dry basis)	Nitrogen	Protein	Phosphorus	Calcium	Magnesium	Silica	Ash
1	Check	518	13	78	1	11	2	3	58
2	Manure	2155	44	273	5	33	7	47	235
3	N+P+K+S(A.P.+P.S.,16-20-48)	5981	136	848	17	107	21	49	641
4	N+S(A.S.21-0-0)	3759	100	625	7	87	14	19	427
6	Lime	1049	22	136	3	20	3	31	121
7	Lime +P(T.Sp.0-43-0)	1738	41	255	5	36	7	24	201
8	P(T.Sp.0-43-0)	1503	35	218	4	28	5	10	159
9	Manure +N+P+S(A.P.16-20-0)	4098	108	673	12	67	13	18	445
10	N+P+S)A.P.16-20-0)	3869	99	617	8	80	14	17	340
11	Check	881	20	127	3	17	3	14	83
14	N+P(A.P.11-48-0)	2448	58	360	7	47	7	11	213
15	N+P+S(S.Sp.2-19-0)	4280	116	722	11	93	17	17	445
16	P+S(S.Sp.0-20-0)	4149	114	712	10	90	17	31	427
17	P(B.M.4-20-0)	1583	30	185	5	23	4	15	108
18	Check	1292	23	146	3	19	4	18	96
19	N(A.N.34-0-0)	1447	33	204	3	26	5	13	123
20	Gyp.+N+S(A.N.34-0-0)	3239	75	466	6	72	12	30	298
21	S(Gyp.)	3418	87	543	6	99	14	19	308
23	S(Sod.S.)	3004	84	527	6	69	11	22	316
24	K+S(P.S.0-0-48)	2681	77	483	6	51	8	11	253
25	N+K+S(P.S.+A.S.,21-0-48)	2830	71	443	5	72	11	10	289
26	Check	1834	44	274	3	40	6	10	192

Table XVIII. Percent Composition of First Year Clovers Grown on Gray Wooded Soil (Oven-dry basis). Data Grouped According to Yield or Treatment.

Breton Series D, 1946.

Plot Description	Plots Included	%N2		% Prot.		%P		%Ca		%Mg		%SiO2		% Ash	
		Rge.	Av.	Rge.	Av.	Rge.	Av.	Rge.	Av.	Rge.	Av.	Rge.	Av.	Rge.	Av.
Checks	1,11,18,26	1.97 2.64	2.44	12.31 16.50	15.22	.20 .32	.25	1.61 2.37	2.09	.32 .43	.37	.57 1.75	1.14	8.13 12.24	10.52
Low Yielders Rec. Phos.	7,8,14,17	2.04 2.56	2.42	12.75 16.00	15.14	.30 .32	.31	1.58 2.28	1.99	.27 .41	.34	.50 1.50	.94	7.43 12.58	10.26
High Yielders Rec. phos.	3,9,10,15,16	2.47 2.99	2.81	15.44 18.69	17.55	.23 .31	.28	1.78 2.37	2.15	.34 .44	.40	.43 .90	.62	9.37 11.82	11.08
All Plots Rec. phos.		2.04 2.99	2.64	12.75 18.69	16.48	.23 .32	.29	1.58 2.37	2.08	.27 .44	.37	.43 1.50	.76	7.43 12.58	10.72
Plots Rec. manure	2,9	2.21 2.86	2.54	13.81 17.88	15.85	.25 .31	.28	1.65 1.78	1.72	.34 .34	.34	.47 2.39	1.43	11.82 11.90	11.86
Sulphur with phos.	3,9,10,15,16	2.47 2.99	2.81	15.44 18.69	17.55	.23 .31	.28	1.78 2.37	2.15	.34 .44	.40	.43 .90	.62	9.57 11.82	11.12
Sulphur without phos.	4,20,21,23, 24,25	2.51 3.14	2.85	15.69 19.63	17.83	.20 .26	.22	2.06 3.15	2.58	.34 .45	.40	.40 1.01	.63	9.81 12.39	10.85
All Rec. sulphur		2.47 3.14	2.83	15.44 19.63	17.70	.20 .31	.24	1.78 3.15	2.38	.34 .45	.40	.40 1.01	.63	9.57 12.39	10.97

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Table XVIII. cont'd.

Plot Description	Plots Included	%N_2		% Prot.		%P		%Ca		%Mg.		%SiO_2		% Ash	
		Rge.	Av.	Rge.	Av.	Rge.	Av.	Rge.	Av.	Rge.	Av.	Rge.	Av.	Rge.	Av.
Nitrogen with phos.	3,9,10,14	2.47 2.86	2.67	15.44 17.88	16.68	.23 .31	.29	1.78 2.26	2.01	.32 .40	.36	.47 .90	.59	9.48 11.82	10.64
Nitrogen without phos.	4,19,20,25	2.46 2.90	2.65	15.38 18.13	16.57	.20 .25	.22	1.96 2.77	2.42	.37 .42	.40	.40 1.01	.74	9.26 12.39	10.70
All Rec. nitrogen		2.46 2.90	2.66	15.38 18.13	16.62	.20 .31	.26	1.78 2.77	2.22	.32 .42	.38	.40 1.01	.66	9.26 12.39	10.67
High Yielders	3,4,9,10,15, 16,20,21,23, 24,25	2.47 3.14	2.83	15.44 19.63	17.70	.20 .31	.24	1.78 3.15	2.38	.34 .45	.40	.40 1.01	.63	9.57 12.39	10.97
Low Yielders	1,2,6,7,8,11, 14,17,18,19 26	1.97 2.64	2.40	12.31 16.50	14.98	.20 .32	.27	1.58 2.37	2.00	.27 .43	.35	.50 3.18	1.35	7.43 12.58	10.62
All Fertilized Plots		2.04 3.14	2.65	12.75 19.63	16.59	.20 .32	.26	1.58 3.15	2.21	.27 .45	.38	.40 3.18	.96	7.43 12.58	10.86
All Plots		1.97 3.14	2.61	12.31 19.63	16.34	.20 .32	.26	1.58 3.15	2.19	.27 .45	.38	.40 3.18	.99	7.43 12.58	10.80

The Nitrogen and Protein Content.

The nitrogen contents range from a minimum of 1.97 to a maximum of 3.14 percent and the proteins vary from 12.31 to 19.63 percent (Table XVI). The crops from plot 24, receiving potassium sulphate and 18, check plot, contain the highest and lowest amounts of nitrogen respectively. The average percentage of nitrogen over the entire series is 2.61 and protein is 16.34. Henry and Morrison (28) give 2.1 and 13.1 percent, and Hopkins (32) gives 2.0 and 12.5 percent of nitrogen and protein as the average amounts contained by red clover. The crops from most of these plots are apparently above average in their content of these constituents.

Only 13 pounds of nitrogen per acre have been removed by the crop grown on the lowest yielding plot. The highest yielder, in contrast, has removed 136 pounds, and many of the better yielders over 75 pounds per acre.

The average nitrogen content (Table XVIII) for all the fertilized crops is 2.65 percent, .25 percent greater than the average for the checks. The effect of fertilizer in general has been to increase the percentage of nitrogen in the clover.

Those fertilizers tending to increase the yield have also encouraged an increase in the nitrogen content of the crop produced, the high yielding plots averaging 2.83 percent and the low yielders 2.40 percent.

The crop grown on the low yielding plots receiving phosphorus contain an average amount of nitrogen comparable to the checks, while a greater amount is found in those crops receiving phosphorus and producing a high yield. The average nitrogen

content of all phosphated plots varies from the average of all plots fertilized by only .01 percent.

The effect of manure applied alone has been to somewhat decrease the nitrogen content of the crop. Its application along with ammonium phosphate (16-20-0) has resulted in an increase of .65 percent nitrogen over the manured plot and a nitrogen content of 2.86 percent.

The average nitrogen content from all the plots fertilized with sulphur is 2.83 percent, those receiving sulphur plus phosphorus showing about the same nitrogen content as those receiving sulphur without phosphorus. The effect of application of sulphur-containing fertilizer in general has been to increase the nitrogen content of the crop from 2.44 to 2.83 percent.

Crops grown on plots receiving nitrogen either with or without additional phosphates show similar nitrogen contents. The average of all plots treated with nitrogenous fertilizers is 2.66 percent nitrogen, .22 percent greater than the average of the checks and very similar to the average of all fertilized plots.

The Phosphorus Content.

The crops grown on the bone meal plot 17 and check plot 11 contain .32 percent phosphorus, the highest amount found in this series. The average content over all the plots is .26 percent and the lowest amount, in the crop from plots 20, 21 and 26 is .20 percent. All of these crops contain more

phosphorus than the average quoted for red clovers by Henry and Morrison (28) and some contain more than the amount given by Hopkins (32).

The maximum amount of phosphorus removed by the crop in this series is 17 pounds per acre and the minimum is 1 pound per acre. Plot 3, which receives potassium sulphate plus ammonium phosphate (16-20-0) has removed the largest amount of this element.

The average phosphorus contents of the check plots, all plots in the series, and all fertilized plots are very similar.

The low yielding plots receiving phosphorus have produced crops containing .31 percent phosphorus, .06 percent higher than the checks and .03 percent greater than the average for the high yielders treated similarly.

The phosphorus content of the manured plot is similar to the check, but where ammonium phosphate (16-20-0) has been applied along with manure, the content has been increased by .06 percent. The percentage of phosphorus in the crop from the plot receiving manure and ammonium phosphate is .05 percent higher than the average for all fertilized plots.

The effect of sulphur fertilizers in general has been to maintain or slightly decrease the phosphorus content of the crop. Those treatments including phosphorus with the sulphur have increased the phosphorus content over the checks by .03 percent, whereas sulphur applied without phosphorus has resulted in a decrease of .03 percent. The effect of the phosphates has been to slightly increase the amount of phosphorus present in the clover.

The average phosphorus content of all plots receiving nitrogen with phosphorus is .29 percent, .04 percent higher than the average of the checks. The content of those plots treated with nitrogen in the absence of phosphorus is .22 percent, or .03 percent lower than the checks. The phosphorus content of all the fertilized crops is the same as the average of those receiving nitrogen. The percentage of phosphorus has been maintained or slightly increased through the use of phosphates along with nitrogenous fertilizers.

There has been very little effect of phosphates in general upon the calcium or magnesium content of clover. A slight increase in the ash, a larger increase in the nitrogen, and a decrease in the silica content have resulted.

The Calcium Content.

Wolff (55) gives 1.70 percent and Henry and Morrison (28) give 1.14 percent as average calcium contents existing in red clovers. The lowest percentage of calcium present in this series is 1.58, with the highest being 3.15. Crops from many of these plots contain over 2 percent calcium and the average of the entire series is 2.19 percent. Most of these crops are well supplied with calcium.

One hundred and seven pounds of calcium per acre have been removed from the highest yielding plot, and 11 pounds from the lowest yielder. More than 50 pounds per acre have been removed in many instances.

Crops from the high yielding plots contain .38 percent more calcium than from the low yielders. The average for all

checks is 2.09 percent, .29 percent lower than the average for the high yielding plots. Factors tending to increase the yield of these clovers have also tended to increase their calcium content.

The average percentage of calcium from all fertilized plots is 2.21 and that of the checks is 2.00. The effect of fertilizers in general has been to increase the calcium content of the crop.

Those crops receiving sulphur with phosphorus contain less calcium than where sulphur is applied in the absence of phosphorus.

Some of the plots receiving calcium in the fertilizers applied have shown increased quantities of this element in the crop, but in other cases, such as plot 4 receiving ammonium sulphate and plot 25 receiving potassium sulphate plus ammonium sulphate, high percentages of calcium with good yields have resulted. This suggests that calcium is not a limiting factor in the production of crops on this soil.

The Magnesium Content.

The magnesium content of the crop from Series D varies from .27 to .45 percent. The highest amount is present in the crop treated with gypsum and the lowest in the bonemeal plot. Plots 1, 4, 7, 15, 16, 21 and 25 all contain over .40 percent magnesium. The average content is .38 percent, somewhat higher than found in the clovers from the other series discussed. This crop contains fairly large amounts of magnesium in comparison with data given by Henry and Morrison (28).

The high yielding plots in this series have produced hay containing .05 percent more magnesium than is present in the low yielders. The factors tending to increase yield have effected a slight increase in the magnesium content of this crop.

No significant effect upon the magnesium content of the clover can be seen as a result of the general use of fertilizers, the treated plots containing an average of .38 percent and the checks .37 percent.

Results from the application of manure suggest a slight depressing effect of this material upon the magnesium content of the crop. No general significant effects can be seen as the result of application of the other fertilizers either alone or in various combinations.

The Silica Content.

The percentage of silica present in the crops from this series ranges from .40 to 3.18. Seven of the plots contain more than 1 percent of this compound. The average over the entire series is .99 percent, somewhat higher than the amounts quoted by Henry and Morrison (28) and Wolff (55) as being usually present in red clover. The presence in the sample of other plants, such as grasses, containing larger amounts of silica may explain this variation.

The general effect of fertilizers is to decrease the content of silica in this clover. The average silica content is higher in the clover from the check plots than from the fertilized plots by .18 percent.

Those factors encouraging high yields tend toward lower silica contents, .72 percent more silica being present in the crop from the low yielding plots than from the high yielders.

The Ash Content.

The percentage of ash varies considerably. The lowest amount is 7.43 percent and the highest is 12.58 percent. The average ash content for the series is 10.80 percent. In comparison with figures given by Henry and Morrison (28) and Wolff (55), these clovers are above average in their content of non-combustible material.

The higher yielding plots contain slightly more ash than do the lower yielders on this series.

A slight increase in the ash content of the crop has resulted with the use of fertilizers, the fertilized crops containing .34 percent more of this constituent than the checks.

Yield and Composition of Alfalfa, Breton, Series H, 1944-46.

The yield of alfalfa (Table XX) for the three years varies from slightly over 1/4 ton to 2 1/4 tons per acre. The average yield of the second cutting in 1944 is considerably less than the first, comparable plots producing only half the amount in the later cutting. From the limited data available, the yield of the 1945 crop appears to be somewhat less than the 1946 crop. Fertilizers containing sulphur have in all cases produced the highest yields on this series. The application of nitrogen and phosphorus has resulted in some yield increases, but sulphur either used alone or in conjunction with the latter elements has given the highest yields.

The nitrogen content (Table XIX) of the second cutting of alfalfa in 1944 is within the range quoted by Henry and Morrison (28) and Hopkins (32) as being average for alfalfa. All other crops on this series are somewhat deficient in this element as compared to the averages given by these authorities. The 1946 crop contains an average of 2.3 percent nitrogen, considerably higher than the first cuttings in the other two years. Very little effect of nitrogenous fertilizers upon the nitrogen content of the crop can be seen. The fertilizers containing sulphur have in many cases produced the crops containing the highest amounts of nitrogen. Apparently those treatments encouraging larger yields have often increased the nitrogen content of the plant.

Henry and Morrison (28) and Hopkins (32) give .24 and .23 percent phosphorus respectively as average amounts present

in alfalfa. Most of the plots dealt with here contain close to these averages. The lowest amount present is .18 percent and the highest amount is .33 percent. The percentage of phosphorus does not appear to have been appreciably affected either by the season or the time of cutting.

The average amount of calcium contained in the alfalfa is very close to the average given by Henry and Morrison (28). The percentage varies from .58 to 2.34, five plots containing less than 1 percent and 3 containing over 2 percent of this element. The second cutting of alfalfa in 1944 contains the highest average amount of calcium. The crop on this series has removed quantities of calcium varying from 4 to 97 pounds per acre per cutting.

The magnesium content on an average has not varied significantly as a result of time of cutting or season. The minimum amount present is .15 percent, the maximum .27 and the majority contain about .22 percent. Hopkins (32) gives .22 percent and Henry and Morrison (28) give .36 percent as average amounts of magnesium found in alfalfa. Most of these crops contain average amounts of this element as quoted by Hopkins, but all are low as compared to the figure given by Henry and Morrison.

These crops contain average amounts of silica compared to data given by Hopkins and Henry and Morrison. The silica content has not varied appreciably between seasons, but appears somewhat lower in the second cutting than in the first. The low yielding plots in most cases contain larger amounts of silica than the high yielders.

The average ash content of the 1946 crop is considerably in excess of the others, the increase being close to 1 percent in most cases. In comparison to data given by Hopkins (32), these crops contain normal amounts of ash, but when compared to Henry and Morrison (28) they all contain less than average amounts of this constituent.

Table XIX. Yield and Percent Composition of Alfalfa Grown on Gray Wooded Soil (Oven-dry basis).

Plot No.	Treatment	Yield lbs. per acre	% Nitrogen	% Protein	% Phosphorus	% Calcium	% Magnesium	% Silica	% Ash
Breton Series H, 1944, Fourth Year Alfalfa, First Cutting.									
16	P+S(S.Sp.0-20-0)	5427	1.86	11.63	.24	.90	.17	.93	7.73
18	Check	1536	1.96	12.25	.29	1.67	.26	1.69	8.03
Breton Series H, 1944, Fourth Year Alfalfa, Second Cutting.									
16	P+S(S.Sp.0-20-0)	2755	2.56	16.00	.24	1.53	.20	.54	6.97
17	P(B.M.4-20-0)	695	2.37	14.81	.32	2.13	.23	.61	7.67
22	Check	695	2.47	15.44	.31	2.04	.22	.48	7.83
23	S(Sod.S.)	2755	2.50	15.63	.20	1.39	.15	.52	7.42
Breton Series H, 1945, Fifth Year Alfalfa, First Cutting.									
16	P+S(S.Sp.0-20-0)	2374	1.45	9.06	.20	.89	.20	.55	5.59
21	S(Gyp.)	4151	1.86	11.63	.18	1.42	.21	.58	6.61
22	Check	1537	1.81	11.31	.31	1.34	.25	2.04	7.83
23	S(Sod.S.)	3803	2.39	14.94	.21	2.00	.25	.53	7.99
Breton Series H, 1946, Sixth Year Alfalfa, First Cutting.									
14	N+P(A.P.11-48-0)	1201	1.72	10.75	.28	1.07	.20	1.20	9.36
15	N+P+S(S.Sp.2-19-0)	1947	2.49	15.56	.27	1.66	.24	.83	9.03
16	P+S(S.Sp.0-20-0)	2832	2.68	16.75	.29	1.87	.27	1.05	9.36
17	P(B.M.4-20-0)	911	1.79	11.19	.31	.97	.21	2.40	8.44
18	Check	625	1.88	11.75	.31	.78	.18	1.72	7.11
19	N(A.N.34-0-0)	684	2.16	13.50	.33	.58	.16	2.35	6.71
20	Gyp.+N+S(A.N.34-0-0	4225	2.62	16.38	.23	1.91	.23	.38	9.17
21	S(Gyp.)	4142	2.62	16.38	.20	2.34	.26	.21	9.60
22	Check	1612	2.32	14.50	.27	1.64	.22	1.14	9.34
23	S(Sod.S.)	4071	2.73	17.06	.20	1.99	.23	.43	8.85
24	K+S(P.S.0-0-48)	3627	2.67	16.69	.22	1.86	.22	.52	8.98
25	N+K+S(P.S.+A.S.21-0-48)	4419	2.76	17.25	.22	1.91	.22	.29	8.89

Table XX. Yield and Composition in Pounds per Acre of Alfalfa Grown on Gray Wooded Soil.

Breton Series H, 1944, Fourth Year Alfalfa, First Cutting.

		Lbs. per acre							
Plot No.	Treatment	Yield (air-dry basis)	Nitrogen	Protein	Phosphorus	Calcium	Magnesium	Silica	Ash
16	P+S(S.Sp.0-20-0)	5572	101	631	13	49	9	50	420
18	Check	1577	30	188	4	26	4	26	123
	Breton, Series H, 1944, Fourth Year Alfalfa, Second Cutting.								
16	P+S(S.Sp.0-20-0)	2878	71	441	7	42	6	15	192
17	P(B.M.4-20-0)	726	16	103	2	15	2	4	53
22	Check	726	17	107	2	14	2	3	54
23	S(Sod.S.)	2878	69	431	6	38	4	14	204
	Breton Series H, 1945, Fifth Year Alfalfa, First Cutting.								
16	P+S(S.Sp.0-20-0)	2515	34	215	5	21	5	15	133
21	S(Gyp.)	4397	77	483	7	59	9	24	274
22	Check	1628	28	174	5	21	4	31	120
23	S(Sod.S.)	4029	91	568	8	76	10	20	304
	Breton Series H, 1946, Sixth Year Alfalfa, First Cutting.								
14	N+P(A.P.11-48-0)	1271	21	129	3	13	2	14	112
15	N+P+S(S.Sp.2-19-0)	2061	48	303	3	32	5	16	176
16	P+S(S.Sp.0-20-0)	2998	76	474	8	53	8	30	265
17	P(B.M.4-20-0)	964	16	102	3	9	2	22	77
18	Check	662	12	73	2	5	1	11	44
19	N(A.N.34-0-0)	724	15	92	2	4	1	16	46
20	Gyp.+N+S(A.N.34-0-0)	4472	111	692	10	81	10	16	387
21	S(Gyp.)	4384	109	678	8	97	11	9	398
22	Check	1706	37	234	4	26	4	18	151
23	S(Sod.S.)	4309	111	695	8	81	9	18	360
24	K+S(P.S.0-0-48)	3839	97	605	8	67	8	19	326
25	N+K+S(P.S.+A.S.21-0-48)	4678	122	762	10	84	10	13	393

DISCUSSION.

The yields of legumes have varied greatly as a result of the application of different fertilizers. Although some variation exists in the check plot yields, the increases obtained by the use of some types of fertilizer have far overshadowed these differences.

In most cases manure applied alone has not produced a very satisfactory yield of clovers, but when used in conjunction with ammonium phosphate (16-20-0) much larger crops have been obtained.

The use of lime has had very little beneficial effect upon the yield of legumes. Its application with triple superphosphate (0-43-0) has produced a slight increase, but insufficient to make the use of such a combination profitable.

The responses obtained by the application of one or both of nitrogen and phosphorus have not been great.

Significant yield increases and satisfactory yields of legumes have been obtained wherever sulphur has been included in the fertilizer, either alone or in combination with other elements. Sulphur appears to be the main limiting element for the production of legumes in this district.

The effect of season is quite marked, the 1946 crop being considerably lighter on an average than the crops of the previous two seasons.

A graphic representation of the average contents of calcium, magnesium, nitrogen, phosphorus, silica and ash present in the red clover-alfalfa mixture over the four series previously discussed can be found on page 83, fig. 2.

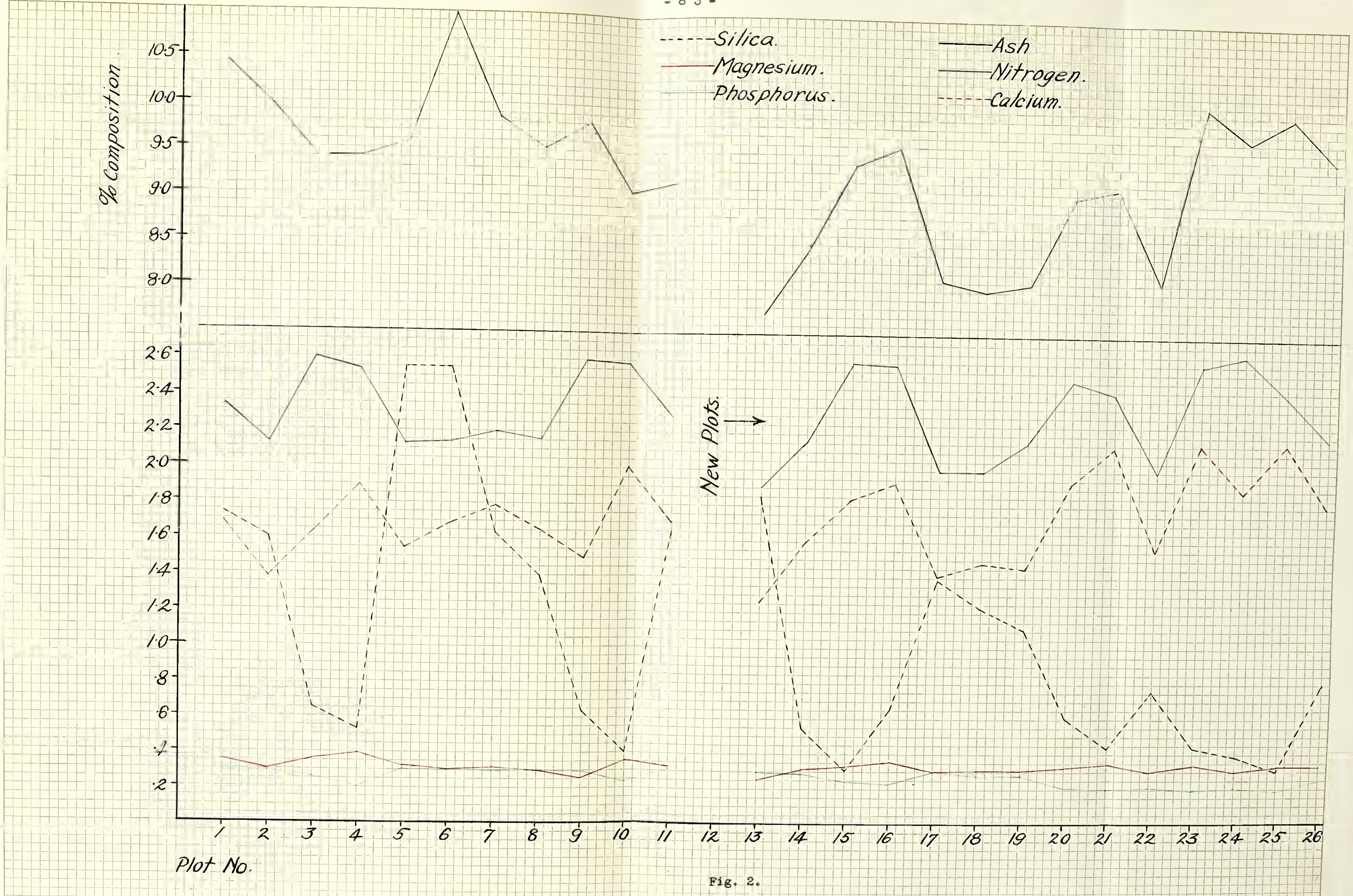

Fig. 2.

Average Percent Composition of Clovers Grown on Gray Wooded Soil, Breton 1944-1946.

The average nitrogen content of the clovers grown in this three year period is somewhat higher than the averages given by Henry and Morrison (28) and Hopkins (32). Nitrogen is not a limiting factor for the growth of clovers on this soil.

The fertilizers which have encouraged increased yields have produced crops with the highest content of nitrogen. It is pointed out that the heavier stands of clovers have contained relatively few non-leguminous plants and the lower yielders have often contained larger proportions of such plants. Since non-legumes are usually lower in nitrogen than legumes, this is suggested as a possible explanation for the smaller amounts of this element found in the crops from the low yielding plots.

The nitrogen content has not been appreciably affected by the presence of fertilizers which have failed to produce increased yields. The plots receiving manure, lime, lime plus triple super phosphate (0-43-0), ammonium phosphate (11-48-0), bone meal and ammonium nitrate all contain average amounts of nitrogen very similar to the checks. Despite the fact that some of these fertilizers supply quite large amounts of nitrogen to the soil, they have not been effective in increasing the nitrogen content of the plant.

The effect of season upon the nitrogen content is quite marked. The 1946 crop contains larger quantities of nitrogen than the other two. However, some of the fertilizers have produced greater variations in the nitrogen content than have the seasons encountered during this three year period.

Examination of the graph shows a fairly close direct correlation existing between the calcium and nitrogen content of

the clovers. Apparently under the field conditions present in this experiment there has been some relationship between the intake of calcium and nitrogen by the plant. Although several workers have shown that it is possible to vary either the calcium or the nitrogen content without affecting the other constituent, where sufficient amounts of both elements are supplied, the rate of intake of one directly affects the intake of the other on this field.

The clovers from the majority of plots have obtained sufficient amounts of available phosphorus. With few exceptions over the period considered the average phosphorus content of the crop has been slightly higher than given by Hopkins (32) and Henry and Morrison (28) as average for red clovers.

In most cases those fertilizer treatments which have produced increased yields have caused a slight decrease in the phosphorus content of the crop. The phosphorus has been utilized more economically by the crop in such instances.

The effect of phosphatic fertilizers upon the phosphorus content of the crop has in general been the same as the effect of all types of fertilizers and the additional phosphorus thus supplied has not increased the content of this element present in the plant.

The overall effect of sulphur application has in three cases out of four been to decrease the phosphorus content of the crop. This may be due more to the increased yield invariably produced through the use of such fertilizers than to any actual inverse effect upon the amount of phosphorus contained in the plant.

In most cases the phosphorus content of the crop receiving both sulphur and phosphorus is higher than that of the crop receiving only sulphur, although not so high as the amount contained in the checks.

An inverse correlation between the quantities of phosphorus and magnesium present in the clovers over the three year period is suggested (graph, page 83). The average content of phosphorus is lower than that of magnesium in almost every case, and the concentration of the one element in the crop has apparently had an inverse effect upon the concentration of the other.

Table XXI. Theoretical Phosphorus Balance in the Soil on Those Plots Receiving Phosphatic Fertilizer. Average of Four Series. Breton Clovers, 1944-1946.*

Plot No.	Phosphorus, Pounds per Acre per Year Amount Removed in Crop	Amount Supplied in Fertilizer	Balance in Soil
2	10.1	12.9	+2.8
3	16.9	8.6	-8.3
7	4.5	12.4	+7.9
8	4.5	12.4	+7.9
9	17.7	22.5	+4.8
10	14.3	8.5	-5.8
14	8.2	12.5	+4.3
15	16.9	8.3	-8.6
16	15.3	3.4	-11.9
17	5.9	11.4	+5.5
Checks	3.9	0	-3.9

*Total annual yield considered as 1.3 x yield of first cutting.

Examination of Table XXI indicates that in every case where medium amounts of phosphorus are being supplied to the soil and satisfactory yields obtained, the phosphorus content of the soil should be slowly decreasing. In the majority of cases

insufficient phosphorus is being supplied to maintain the original content in the soil and at the same time produce good yields.

The average calcium contents of the four different series of clovers discussed here are all equal to or slightly above the amounts considered to be average for such a crop. The clover hays from this field are well supplied with calcium.

Any effect of fertilizers containing calcium upon the content of this element in the plant is not apparent. In some cases these fertilizers have produced crops containing fairly high percentages of calcium, but many plots treated otherwise contain equally as large amounts.

With the exception of 1944, the effect of those fertilizers producing increased yields has been to increase the calcium content of the plant. The factors stimulating the crop growth have apparently also stimulated the rate of calcium intake by the plant in three cases out of four.

There is some indication of a direct correlation between the magnesium and calcium contents (graph, page 83). The only actual exception is plot 6, where the magnesium has decreased and the calcium has increased. In the case of plots 19 and 26 the magnesium has remained constant while the calcium has decreased.

In all cases the average magnesium content of the clovers on the different series is larger than the amounts given by Henry and Morrison (28) as average for red clovers. Series D, 1946, contains a larger average amount of this element, but the contents of the other three series are nearly alike. Seasonal variation has apparently not appreciably affected the magnesium content of these clovers.

The crop from plot 4, receiving ammonium sulphate, has in every instance contained relatively high amounts of magnesium. The only other plot receiving regular treatment with ammonium sulphate is plot 25, which also receives potassium sulphate, and in this case the magnesium content has not been consistently increased by the ammonium sulphate application.

The use of fertilizers in general has had no appreciable effect upon the average magnesium content of the crop.

The first year clovers on Series D, 1946, have had a slight increase in average percentage of magnesium as a result of the application of those fertilizers which produce larger yields. In the other series no change in the magnesium content has been effected by the use of such fertilizers.

The silica content of the clovers is higher in almost every instance than the averages given by reliable sources for red clovers. It is pointed out that no attempt was made to separate the legumes from the non-legumes so that in the case of some of these plots the silica content may have been increased by the presence of non-leguminous plants. Since the silica recorded as such in this report is actually the insoluble residue of the plant, it may contain small amounts of other insoluble compounds.

The lowest average amounts of silica have in all cases been present in the high yielding crops. Although the higher yielders contain a larger proportion of legumes to non-legumes, it is doubtful whether this fact will entirely account for the large variation present.

Seasonal variation has been quite effective in varying the ash content of the hay. The average ash content of the 1946 crop is over 2 percent higher than that of either of the preceding years.

In some series increased yields have produced increased average ash contents but in other series the reverse has been true.

From the limited data available it appears that the second cutting of a mixed red clover-alfalfa crop produces about half the yield of the first cutting. The nitrogen content of the second cutting is considerably higher and the phosphorus, calcium, magnesium and ash contents are also somewhat higher. The silica content is slightly lower for the second cutting.

Those fertilizers producing the best yields in the red clover-alfalfa mixture also produce the best yields of alfalfa grown alone. The average yield of alfalfa over a three year period is somewhat lower than the corresponding yield for the mixture.

The 1946 alfalfa crop contains considerably more nitrogen than the other two seasons' crops. This was also noted for the red clover-alfalfa mixture. Although the fluctuation due to season is not so marked as the fluctuation due to different fertilizers, the effect of season upon the nitrogen content is quite great.

With the exception of the second cutting, 1944, the alfalfa grown on the Breton field contains somewhat less than the average amounts of nitrogen and magnesium given by Henry and Morrison (28), but an amount of magnesium comparable to the figure given by Hopkins (32). The phosphorus and calcium contents are very similar to the amounts given by these authorities.

The ash content of the 1946 alfalfa crop is considerably in excess of the content for the previous two seasons.

On an average the alfalfa hay contains less magnesium and somewhat less nitrogen and calcium than the combined alfalfa and red clovers. The phosphorus contents are very much alike.

Larger nitrogen contents of barley hay have been obtained in a rotation including legumes than in a straight grain-fallow system. The barley nursing clovers grown on the land three years after clovers have been plowed under, contains less nitrogen than the crop grown the second year after clovers.

The barley hays contain an average of .30 percent phosphorus, .19 percent magnesium, 1.72 percent nitrogen and .45 percent calcium. They contain less magnesium, nitrogen and calcium and more phosphorus than the legumes grown in the same area on a very similar type of soil.

From a nutritional standpoint barley cut at this stage of maturity has a favorable feeding value.

SUMMARY.

Yields and percent nitrogen, protein, phosphorus, calcium, magnesium, silica and ash of 102 samples of mixed clover-alfalfa hay produced over a three year period, 22 samples of alfalfa produced over a similar period, and 24 samples of barley green feed produced in one season, are presented. These crops were grown on gray wooded soil and treated with different fertilizers.

Seasonal variation affects the average yield quite markedly. The yield, as affected by fertilizers, varies to a much larger extent and is greatest when sulphur is contained in the fertilizer.

The red clover-alfalfa mixture is somewhat richer in content of all the elements determined than the amounts given as average by reliable authorities. The feeding value of the barley hay is quite high. The alfalfa is somewhat below average in its content of nitrogen and possibly magnesium.

The nitrogen content of the clovers from the high yielding plots is considerably greater than from the low yielders. When they produce increased yields, fertilizers have more effect upon the nitrogen content of the clover hay than do seasonal variations.

Fertilizers containing only nitrogen have not increased the nitrogen content of the crop.

The average nitrogen content of barley hays grown in a rotation including legumes is higher than in a grain-fallow system.

A direct correlation between the nitrogen and calcium content of the clover crop exists in most cases.

Generally, increased yields have resulted in a slight decrease in the phosphorus content of the crop.

The phosphorus content of the soil from those plots receiving average applications of phosphatic fertilizers and producing good yields is not theoretically being maintained.

In three cases out of four, increased calcium contents of clovers have occurred with increased yields.

An indirect correlation between the magnesium and phosphorus content of clovers is suggested.

Neither seasonal nor yield variations in general have had an appreciable effect upon the magnesium content of clovers.

The average silica content in the clovers from the low yielding plots is greater than from the high yielders.

The ash content of clover and alfalfa hays is appreciably affected by seasonal variations.

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